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ART. I.—*On the Suspension and Sedimentation of Clays;* by WM. H. BREWER.

IN a paper read before the National Academy of Sciences in 1883, and since published,* I have considered some of the general phenomena of sedimentation and given a partial account of experiments pertaining to the subject. Clays and the materials suspended from soils and from pulverized rocks formed part of the substances experimented on and discussed.

The continuation of the experiments then in progress confirms and extends the conclusions there stated, and this article with a succeeding one may be considered as a review and continuation of the previous paper, so far as it specially relates to the transportation of mud in natural waters and the formation of bars and deltas. In this paper I will consider the behavior of clays toward water, as shown by laboratory experiments, and in the next, the application of the same in explanation of the natural phenomena.

Erosion by running water, the transportation of suspended mud, its deposition, the formation of bars in rivers or at their mouths, the growth of deltas, the distribution of silt in lakes and harbors and on the floor of the ocean have mostly been discussed from the mechanical side only. The chemical aspects of the phenomena have usually either been but lightly considered or entirely ignored.

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* "On the Subsidence of Particles in Liquids;" Memoirs of the Nat. Acad. Sci., vol. ii.

The transportation and deposition of gravels and coarse sands are probably in accordance with well-known hydraulic laws, in which the velocity of the current, the specific gravity, and the relative weight and surface of the transported materials are the only factors that need be considered in any practical discussion. But with those finer particles of disintegrated rocks which are ultra-microscopic in size and all those which though still coarser are small enough to be subject to those movements in liquids known as the "Brownian motions," and with the true clays I consider that chemical conditions rather than mere motion of the water are the controlling factors.

I have carried on a long series of experiments on the sedimentation of clays, and the finer portions of soils and pulverized rocks, mostly in tall precipitating flasks in which the materials were first agitated with the respective liquids and were then allowed to stand at rest under various conditions as to light, temperature, etc.

There is considerable difference as to details in the behavior of various clays in water. With some of them, if agitated and thoroughly diffused through the liquid and then allowed to stand at rest, the turbidity fades gradually and regularly in density from the bottom to the top, and the liquid gradually grows clearer until it becomes as clear as natural waters ever do. Usually however, and with the great majority of clays (if the water be pure enough), the deposition is in quite a different manner. After some time, it may be in a few hours or it may be only after some days, the suspended material disposes itself in layers or strata which are more or less obvious because of the different degrees of turbidity of the liquid. There may be but two or three of these layers to be seen at once or there may be six or eight, the number depending in part on the composition and fineness of the material under experiment, in part on the freedom of the water from other dissolved material than the clay itself, and in part on the temperature. Some of these layers may be and usually are very obvious, others obscure and only to be seen in the best light; some are very sharply defined, others remain ragged and ill defined along the line of separation. Some which may be obscure at one temperature become sharp and well-defined if the temperature be slowly raised or lowered a few degrees, or well-defined strata at one temperature become first hazy and then disappear at a higher or lower temperature. Sometimes, with a change of temperature, what was before one uniform stratum will slowly resolve itself into several obvious strata, which remain distinct so long as the temperature is right, but which disappear again and become homogeneous at another temperature. Thus, some suspended clays may be induced to exhibit a much larger number of these liquid strata in the aggregate than are visible at any one time.

These different strata, having unlike degrees of opacity, settle with very different degrees of rapidity, and if the temperature be kept nearly constant and the vessel entirely at rest, their number grows less and less from the more rapid settling of the lower and heavier. The lighter ones usually settle with extreme slowness often but a millimeter per day, some even less than half that, and consequently, any cause, such as varying temperature, which sets up even very feeble currents, may so retard the ultimate clearing as to indefinitely prevent it.

If the vessel be kept in the quiet and with as nearly constant temperature as is possible, the liquid finally becomes uniformly opalescent throughout. This opalescence gradually fades for a time, from the subsidence of some of the suspended matter, and if the water contains a sufficient amount (which may be a very minute proportion) of certain salts in solution, it becomes practically clear, that is, clear to the unaided eye in ordinary daylight,—as clear as the clearest natural waters. If, however, the water be free from dissolved substances (other than the clay itself) the fading of the opalescence ceases after some time, it may be in a few weeks or it may be only after two or three years, and after that the liquid becomes no clearer by standing. The degree of opalescence may and often does vary with varying temperature, as if some of the sediment were again picked up, or as if a portion which had fallen and remained as a mobile liquid stratum on the bottom at one temperature were again raised by diffusion at another temperature. Certain very ferruginous clays under experiment, the later suspensions from which are amber-colored, change thus very decidedly and obviously from summer to winter in a vessel which is kept in the temperature of my study. In pure water the subsidence is probably never complete. Some specimens under experiment, which have stood more than seven years and which are still obviously opalescent, have not become sensibly clearer for the last four years. The last portion of this time they have rested on a shelf fastened to a heavy wall in a deep cellar and further enclosed in a closet, in which changes of temperature are very slow, and jars or motion practically none.

In the presence of mineral acids and various salts (and numerous substances not classed as salts or acids), the behavior of suspended clays is very different. If a small quantity of mineral acid, or some saline substance be added to muddy water, the strata described are either not formed at all, or are fewer and settle more quickly. If the quantity of dissolved material is sufficient, the clay curdles or flocculates and immediately falls to the bottom. If now the clear saline (or acid) liquid be decanted from the sediment, an equal quantity of distilled water be added and the mud again diffused by agitation, the clay again allowed to settle, the liquid again decanted when clear, and this process repeated over and over, the saltness (or acidity as the case may be) of the liquid growing less with each dilution, we may study the behavior of the same portion of clay in solutions of different (and known) degrees of strength, and by repetition with the same clay in the same vessel, over a sufficiently long period of time, we may imitate the conditions which take place in the erosion and transportation of muds by rivers and their ultimate deposit in the sea.

From such experiments we may say in a general way, that the more saline the suspending water, the more rapid the sedimentation, but the rapidity of preciptation is not directly proportionate to the quantity of salts dissolved. Reducing the saltness one-half does not double the time of precipitation, and the precipitation is comparatively rapid until the solution is very weak indeed. With some clays the precipitation is as complete in thirty minutes in sea water as in thirty months in distilled water. This completeness of precipitation refers to the actual clearing of the liquid, and not the rate of deposition of the first and heavier portions.

The experiments are more striking if conducted with acids, they acting with greater intensity than salts. The successive phenomena are similar in character, and differ only in degree, the later changes are more rapid and the final suspension is more striking. For example, if we begin with a strong solution of sulphuric, nitric and chlorhydric acids mixed, and follow through repeated dilutions as above described, the flocculation and precipitation of the suspended material is almost equally rapid for several successive dilutions, and the layers or strata only appear in the suspensions when the proportion of free acid becomes minute, and with this the precipitation becomes very much slower. Finally (and this point is reached somewhat suddenly) the behavior is as in distilled water. Many strata are formed of the suspended matter, the settling of all of them is very much slower and complete clearing of the liquid is indefinitely postponed. In fact, this stratification and long suspension of clays is best seen in specimens that have thus undergone treatment with acids or salts, and then washed with distilled water through successive dilutions.

The behavior of these finer suspensions is analogous to that of a colloid. The diffusion through water is like that of a colloid, and when the finer portions are evaporated slowly and at low temperatures, they are at first very bulky and colloidal in appearance, shrinking enormously on drying into a mass curiously like some organic colloids. If the clay is not strictly colloidal, it is indeed very like it, and its behavior toward water very similar.

The continuation of the experiments since, the preparation of the paper cited, confirms the conclusions there suggested, viz: that clays probably exist as a series of hydrous silicates, feebly holding different proportions of water in combination and having different properties, so far as their behavior to water is concerned. That some of them swell up in water (much as boiled starch does) more than others and are diffusible in it with different degrees of facility, that this diffusion is in part at least, analogous to that of colloids in water, that the strata observed in the suspension represent members of this series of chemical compounds which hold their different proportions of combined water very feebly and are stable under a very limited range of conditions. That they are destroyed or changed in the presence of acids, salts and various other compounds, and that they are stable only under certain conditions of temperature, some which may exist at one temperature being changed to others or destroyed at another temperature.

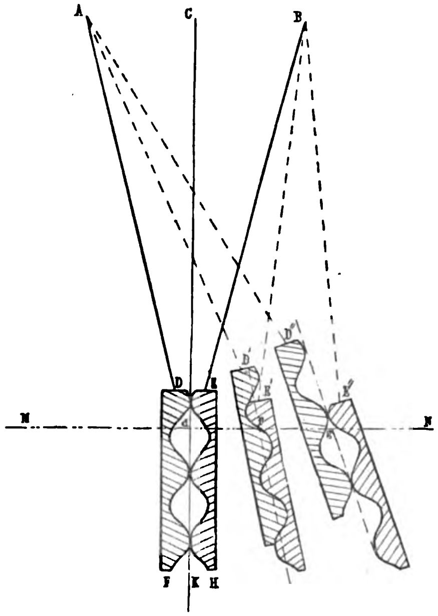
The special bearing of the experiments and conclusions on certain geological phenomena, especially the transportation of suspended mud and the formation of bars and deltas, will be considered in another paper.

Art. II.—*On a method of illustrating the formation of Diffraction Bands;* by S. T. Moreland.

The following method of illustrating the formation of bright and dark bands in diffraction phenomena has proved very satisfactory in my own teaching and I give it with the hope that others may find it useful. The method is shown in the accompanying figure, which hardly needs any explanation. A and B represent two luminous points from which start two disturbances having the same *phase* and the same *wave-length*. DF and EH are two pieces of thin board, one side of each having the form of a simple harmonic curve. DA and EB are two wires or cords of the same length. By moving the two pieces of board in the plane of the paper with the curved edges in contact and the wires always tight we readily find one series of points as *d* and *g* where crests coincide with crests. These points correspond to bright lines in diffraction. We also find another series of points, one between each two of those just mentioned as *f*, where crests coincide with troughs, and hence correspond to dark bands. The following are some of the laws of diffraction phenomena that may be proved, or at least illustrated, by this piece of apparatus:—

1. The distance between the bands increases as the distance AB diminishes. This is shown by simply varying the distance AB.

2. Other things being the same, the distance between the bands is greater the greater the *wave-length* of the light employed. This may be shown by having another pair of pieces representing a different *wave-length.* We may also infer the effect of using white light.



3. The bright points are so situated that the difference of their distances from the two centers of disturbance is a multiple of the *wave-length;* while for the dark points these differences are multiples of half the *wave-length.* Other points might be mentioned but these are sufficient.

No attempt has here been made to describe methods of getting the bands themselves by using light, because the necessary directions may be found in a number of books. Nor have I pointed out the limitations and inaccuracies in the method of illustration. These will readily occur to any one using it. So far as this piece of apparatus is concerned what I have assumed to represent a bright line might be taken for the dark one by making only a slight change in the pieces of board.

Lexington, Va.

ART. III.—*On a System of Rock notation for Geological diagrams;* by JAMES D. DANA.

IN geological diagrams it is often desirable that the kinds of rock should be indicated as well as their position. The following method of accomplishing this purpose is both simple and definite, and I think it will be found suited to general adoption. I have been led to the subject by the necessity of preparing many diagrams to illustrate an account of my recent observations on the stratigraphical relations of the Green Mountain formations.

In selecting the symbols, the fact that a sandstone is usually represented by a dotted surface suggested for quartz a dot (·); and another fact, that a slate or shale is indicated by parallel lining, suggested the use not only of such lining for shale or slate, but further of a short line like a hyphen (-) for mica; of a similar line three times as long (—) for hydrous mica (damourite, etc.), hydromica or sericite schist being intermediate in aspect between a slate and a mica schist.

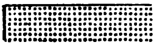
To these symbols, I add a cross (+) for orthoclase feldspar; a cross in oblique position (×) for a triclinic feldspar or plagioclase; and the same cross with a line at bottom for a basic feldspar, andesite, labradorite or anorthite, when it is desirable to recognize the distinction.

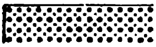
The other more common of the essential constituents in rocks are hornblende, augite, hypersthene, chrysolite or olivine, leucite and glass. For hornblende an *n* is used; for augite, *u*; for hypersthene when a predominant constituent, *y*; for olivine, *v*; for leucite, *l*; for glass, *o*.

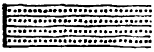
To distinguish thin schistose structure or slaty bedding, a rule is inserted between the lines of symbols; for thick schistose, gneiss-like, a rule is inserted at intervals of 2 to 4 lines of symbols; and for massive structure where bedding is recognizable, a rule at intervals of 6 or more lines of symbols or without rules.

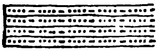
No attempt is made to distinguish varieties of the different rocks dependent on accessory ingredients, as this would make the system cumbrous and impracticable. The following figures illustrate the method:

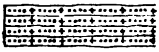
I. *Rocks whose essential constituents are quartz, mica, orthoclase, singly or in combination.*

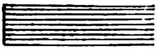

1. **Massive quartzyte (or quartzose sandstone).**

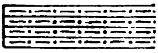

2. **Conglomerate.**

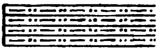

3. **Thin-bedded quartzyte (or sandstone).**

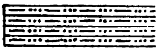

4. **Micaceous quartzyte.**

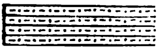

5. **Feldspathic quartzyte.**

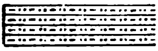

6. **Phyllyte (argillyte).**

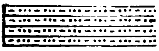

7. **Hydromica schist.**

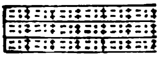

8. **Quartzytic or arenaceous hydromica schist.**

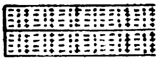

9. **Very quartzytic hydromica schist.**

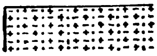

10. **Mica schist (with little or no feldspar).**

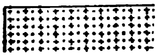

11. **Quartzytic or arenaceous Mica schist.**

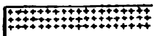

12. **Very quartzytic Mica schist.**

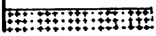

13. **Gneiss, thin-bedded.**

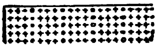

14. **Gneiss, thick-bedded.**


15. **Granite.**


16. **Granulite (mica-less granite).**

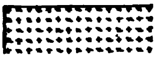

17. **Felsyte.**


18. **Quartz-felsyte.**

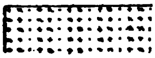

19. **Trachyte.**

20. **Quartz-trachyte: same as 19, with the addition of the dot for quartz.**
21. **Gneissoid mica schist: same as 13 with the addition of a rule beneath each line of symbols.**

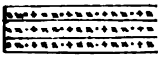
II. *Hornblendic rocks, containing hornblende alone, or with quartz or orthoclase, or with both.*



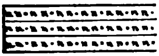
1. Syenyte.



2. Quartz-syenyte.



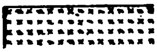
3. Hornblende schist.



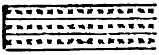
4. Hornblende schist with little or no orthoclase.

5. Hornblendyte without bedding: the symbol *n* without alternate rules.
6. Syenyte or hornblende gneiss: same as 2, with a rule at intervals of 2 to 4 lines of symbols.

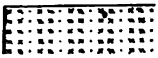
III. *Rocks containing a triclinic feldspar (plagioclase) with hornblende, augite, hypersthene.*



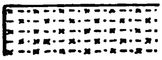
1. Dioryte.



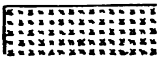
2. Dioryte schist.



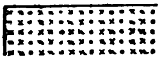
3. Quartz-dioryte.



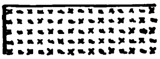
4. Hemidioryte (mica-dioryte) containing quartz.



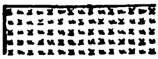
5. Labradioryte (labradorite dioryte), anorthite-dioryte



6. Andesyte.



7. Augite-dioryte.

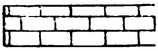


8. Doleryte, diabase, gabbro.

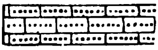
9. Hemidioryte without quartz (mica-dioryte): like 4 with the dot omitted.
10. Augite-andesite: like 6 with *u* in place of *n*.
11. Noryte: like 7 with *y* in place of *u*.
12. Dacyte: like 4 with the symbol for glass added.
13. Basalt: like 8 with the symbol for glass added.

The coarsely crystallized gabbro, common in Archæan regions, might be distinguished in symbol from doleryte or diabase by making the symbol for the basic feldspar of large size in proportion to the other letter. The typical euphotide of the Alps, etc., representing one section of gabbro, is a different rock in constitution in not containing a feldspar as a characteristic constituent, and should have a different symbol. Further, the symbol for an acidic plagioclase might be made distinct from that for plagioclase in general by adding a vertical line between the two upper bars of the cross.

IV. *Calcareous rocks.*



1. Limestone.



2. Quartzytic or arenaceous limestone.

3. Argillaceous limestone: like 2, with a line in place of the dots.

The above are examples of the proposed system of symbols. For rocks not included above, other symbols in accordance with the system may readily be devised, where the science requires them.

Art. IV.—*The Crystalline Rocks of the Scottish Highlands;* by Archibald Geikie.

Ever since the discovery of Silurian fossils in the rocks of Northwest Sutherland, it has been recognized that in that region lies the key to the structure of the Scottish Highlands. Accordingly, when in the progress of the Geological Survey, the mapping of the Highlands had to be undertaken, I determined that a detailed survey of the Sutherland ground on the scale of six inches to the mile should be made as a basis for the work. In the summer of last year a surveying party under the charge of Mr. B. N. Peach was stationed there, with instructions to begin by mapping the Durness Basin. This duty was satisfactorily accomplished before the end of the season. The Silurian series of Durness was ascertained to be about 2,000 feet thick, and to consist of numerous successive zones, which were traced on the six-inch maps and discriminated in such a way as to be recognizable should they be found to occur in the more complicated region to the east. With this necessary groundwork well established, the Eriboll tract was attacked this summer by Messrs. Peach and Horne. I had never myself had an opportunity of studying the Eriboll sections, which, from the days of Macculloch down to the present time, have been such a fruitful subject of discussion. It was a special injunction to the officers now intrusted with the detailed survey of the region to divest themselves of any prepossessions in favor of published views and to map the actual facts in entire disregard of theory. By the close of this last season the structure of the Eriboll area had likewise been traced upon the six-inch maps, and I then went north to inspect the work. From time to time during the summer, reports had been made to me of the progress of the survey, but, though from the published descriptions of the tract, I was aware that its structure must be singularly complicated, and although apprised of the conclusions to which the surveyors, step by step and almost against their will, had been driven, I was hardly prepared for the extraordinary geological structure which the ground itself presented, or for the great change necessitated in the interpretation of the sections as given by Murchison.

No one cursorily visiting the ground could form any notion of its extraordinary complication, which could only be satisfactorily unravelled by patient detailed mapping such as had never yet been bestowed upon it. With every desire to follow the interpretation of my late chief, I criticised minutely each detail of the work upon the ground; but I found the evidence altogether overwhelming against the upward succession which Murchison believed to exist in Eriboll from the base of the Silurian strata into an upper conformable series of schists and gneisses. The nature of this evidence will be best understood from the subjoined report, which, at my request, Messrs. Peach and Horne have prepared. As the question of the succession of the rocks in the Northwest Highlands is still under discussion, I think it right to take the earliest opportunity of making this public declaration. It would require more space than can be given in these pages to do justice to the views of those geologists, from Nicol downward, by whom Murchison's sections have been criticised, and to show how far the conclusions to which the Geological Survey has been led, have been anticipated. When the official memoirs are published, full reference will be given to the work of previous observers, to which, therefore, no further allusion is made at present.

The most remarkable features in the Eriboll area are the prodigious terrestrial displacements, to which there is certainly no parallel in Britain. Beginning with gentle foldings of the rocks, we trace these becoming increasingly steeper on their western fronts, until they are disrupted and the eastern limb is pushed westward. By a system of reversed faults, a group of strata is made to cover a great breadth of ground and actually to overlie higher members of the same series. The most extraordinary dislocations, however, are those to which for distinction we have given the name of Thrust-planes. They are strictly reversed faults, but with so low a hade that the rocks on their up-throw side have been, as it were, pushed horizontally forward. The distance to which this horizontal displacement has reached, is almost incredible. In Durness, for example, the overlying schists have certainly been thrust westward across all the other rocks for at least ten miles. In fact, these thrust-planes, but for the clear evidence of such sections as those of Loch Eriboll, could not be distinguished from ordinary stratification-planes, like which they have been plicated, faulted, and denuded. Here and there, as a result of denudation, a portion of one of them appears capping a hilltop. One almost refuses to believe that the little outlier on the summit does not lie normally on the rocks below it, but on a nearly horizontal fault by which it has been moved into its place. Masses of the Archæan gneiss have thus been thrust up through the younger rocks and pushed far over their edges. When a geologist finds vertical beds of gneiss overlying gently inclined sheets of fossiliferous quartzite, shale and limestone, he may be excused if he begins to wonder whether he himself is not really standing on his head.

The general trend of all these foldings and ruptures is from north-northeast to south-southwest, and the steep westward fronts of the folds show that the terrestrial movement came from east-southeast. Corroborative evidence that this was the direction of the movement is furnished by a series of remarkable internal rearrangements that have been superinduced upon the rocks. Throughout the whole region, in almost every mass of rock, altogether irrespective of its lithological characters and its structure, striated planes may be noticed which are approximately parallel with the thrust-planes, and are covered with a fine parallel lineation, running in a west-northwest and east-southeast direction. These surfaces have evidently been produced by shearing. Again, many of the rocks near the thrust-planes, and for a long way above them, are marked by a peculiar streaked structure which reminds one of the fluxion-lines of an eruptive rock. The coarse pegmatites in the gneiss, for example, as they come within the influence of the shearing, have had their flesh-colored feldspar and milky-quartz crushed and drawn out into fine parallel laminæ till they assume the aspect of a rhyolite in which fluxion-structure has been exceptionally well developed. The gneiss itself coming into the same powerful mill has acquired a new schistosity parallel with the shearing-planes. Hornblende-rock has been converted into hornblende-schist. Moreover, new minerals have likewise made their appearance along the new divisional planes, and in many cases their longer axes are ranged in the same dominant direction from east-southeast to west northwest.

Murchison believed that the Silurian quartzites and limestones of Eriboll pass up under, and are conformably overlain by, his upper gneiss. It is quite true that they are so overlain; but the overlying rocks, instead of having been regularly deposited on them, have been pushed over them. What, then, are these overlying rocks? Though they have undergone such intense alteration during the process by which they were moved into their present position that their original characters have been in great measure effaced, lenticular bands occur in them which can certainly be recognized. Some of these bands are unquestionably parts of the Archæan gneiss; others are Silurian quartzite, and in one case we can detect a large mass of the Upper Durness limestone. Traced eastward, however, the crystalline characters become more and more pronounced until we cannot tell, at least from examination in the field, what the rocks may originally have been. They are now fine flaggy micaceous gneisses and mica-schists, which certainly could not have been developed out of any such Archæan gneiss as is now visible to the west. Whether they consist in part of higher members of the Silurian series in a metamorphic condition remains to be seen. The occurrence of a band of crystalline limestone and calcareous schist, which has been traced for many miles above the great thrust-plane, certainly suggests that it represents the upper part of the calcareous Durness series attenuated and altered by the intense shearing which all the rocks have undergone. This much at least is certain, that the schistose series above the thrust-plane is partly made up of Silurian strata, and has received its present dip and foliation since Silurian time.

Having satisfied myself that Murchison's explanation of the order of sequence could not be established in Eriboll, I was desirous to see again, in the new light now obtained, some of the Ross-shire sections for the description of which I am responsible. Had these sections been planned for the purpose of deception they could not have been more skillfully devised. The parallelism of dip and strike between the Silurian strata and the overlying schists is so complete as to prove the most intimate relationship between them; and no one coming first to this ground would suspect that what appears to be a normal stratigraphical sequence is not really so. But the clear coast-sections of Eriboll, where every dislocation is laid bare, have now taught me that I have been mistaken, for the parallelism in question is not due to conformable deposition. The same kind of evidence of upthrust and metamorphism which these coast-sections reveal can be traced southward for a distance of more than ninety miles. The task of unraveling the geological structure of these southern regions will be much facilitated by the remarkable persistence of the Sutherland Silurian zones, some of which, with their characteristic features and fossils, are as well marked above Loch Carron as they are at Loch Eriboll.

In southwestern Ross-shire the platform on which the Silurian rocks rest is a thick mass of Cambrian red sandstone. In the great upthrow, it is this sandstone platform which has there been pushed over the limestones and quartzites. On the west side of Loch Keeshorn, the red sandstones, in their normal unaltered form, rise up into the colossal pyramids of Applecross; but on the east side, where, at a distance of little more than a mile, they overlie the limestones, they bear so indurated an aspect that they have naturally been classed with the quartzose members of the Silurian series. Traced eastward they present increasing evidence of intense shearing; fluxion-structure makes its appearance in them, with a development of mica along the divisional planes, until they pass into frilled micaceous schist, in which, however, the original clastic grains are still recognizable. They finally shade upward into green schists and fine gneiss which merge into coarse gneiss with pegmatite. The short space within which ordinary red feldspathic sandstone and arkose acquire the characters of true schists is a point of some importance in regard to the change from the unaltered Silurian strata of the Southern Uplands into the metamorphic condition of the Highland phyllites, grits, etc.

Obviously the question of chief importance in connection with the structure now ascertained to characterize the North-West Highlands relates to metamorphism. That there is no longer any evidence of a regular conformable passage from fossiliferous Silurian quartzites, shales and limestones upward into crystalline schists, which were supposed to be metamorphosed Silurian sediments, must be frankly admitted. But in exchange for this abandoned belief, we are presented with startling new evidence of regional metamorphism on a colossal scale, and are admitted some way into the secret of the processes whereby it has been produced.

From the remarkably constant relation between the dip of the Silurian strata and the inclination of their reversed faults, no matter into what various positions the two structures may have been thrown, it is tolerably clear that these dislocations took place before the strata had been seriously disturbed. The persistent parallelism of the faults and of the prevailing northeasterly strike of the rocks indicates that the faulting and tilting were parts of one continuous process. The same dominant northeasterly strike extends across the whole Highlands, and also over the Silurian tracts of Southern Scotland and the north of England. There is reason to regard it in all these regions as probably due to one great series of terrestrial movements. These must have occurred some time between an early part of the Silurian period and that portion of the Old Red Sandstone period represented by the breccias and conglomerates of the Highlands. In the Central and Eastern Highlands the slates, phyllites, grits, quartzites, and limestones which, along the southern border, are scarcely more altered than their probable equivalents among the Silurian rocks of the Southern Uplands, have been greatly plicated, and have assumed a more or less crystalline structure. But when these changes were brought about, there lay to the northwest a solid ridge of Archæan gneiss and Cambrian sandstone which offered strong resistance to the plication. The thrust from the eastward against this ridge must have been of the most gigantic kind, for huge slices, hundreds of feet in thickness, were shorn off from the quartzites, limestones, red sandstones, and gneiss, and were pushed for miles to the westward. During this process, all the rocks driven forward by it had their original structure more or less completely effaced. New planes, generally parallel with the surfaces of movement, were developed in them, and along these new planes a rearrangement and recrystallization of mineral constituents took place, resulting in the production of crystalline schists. This metamorphism certainly occurred after early Silurian times, for Cambrian and Lower Silurian strata, as well as Archæan rocks, have been involved in it.

It is obvious that into the problems of Highland geology, always admittedly obscure, a fresh element of difficulty is introduced. At the same time the aid furnished by a minute study of the Sutherland sections is so great that we may hope to attack these problems with more success than has hitherto seemed probable. The work, too, is not of a kind to be attempted in a few hasty scampers over the ground. It will require patient, detailed mapping. But when the great baselines have once been accurately traced, the difficulties will doubtless begin to diminish, and, like the piece of a puzzle, the various segments of the Highlands will then be found to range themselves in their proper places.—*From Nature*, Nov. 13.*

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* For extracts from the report of Messrs. Peach and Horne, and a stratigraphical section of the fault region, see beyond.

ART. V.—*Observations upon the Great Fault in the vicinity of Schodack Landing, Rensselaer County, N. Y.*; by S. W. FORD.

IN an earlier paper by the writer, upon the age of the rocks in the vicinity of Schodack Landing (this Journal for September, 1884), the exact course of the great fault referred to, or, in other words, the precise age of a ledge of slaty rocks a short distance south of the more southerly promontory therein described, was left in some uncertainty. The question was considerably complicated by the failure, in the first instance, to obtain fossils from the rocks in dispute, and, as will be seen further on, by the extraordinary position of the adjacent beds. I have recently spent several days in a careful study of the vexed locality, and in further examinations of the rocks of the neighborhood; and the additional facts obtained form the subject-matter of the present article.

It is not often that one is permitted to observe the slates or schists of the early Cambrian overlying in apparent conformity those at the summit of the Lower Silurian, and yet such is the case in the locality which I am about to describe.* Along the western bases of Snake and Buck mountains in Vermont, and also in the hills east of Troy and Lansingburgh, New York, the evidences of a great fracture resulting in practically the same phenomena as those hereinafter mentioned are very conclusive; but in none of the localities cited has the actual contact of the older and newer groups been observed. In order to render the subject clearer to those who may be unacquainted with the region, I have introduced the annexed sketch-map, the geologically characterized portion of which represents a tract about three miles in length, with an average breadth of three-quarters of a mile. It lies, as will be noted, partly in Rensselaer and partly in Columbia county, along the eastern shore of the Hudson River.

The dotted area of the map represents that portion of the district occupied by the Lorraine Shales (= Hudson River Group),† and the particular portions of it, A, A′, the two prom-

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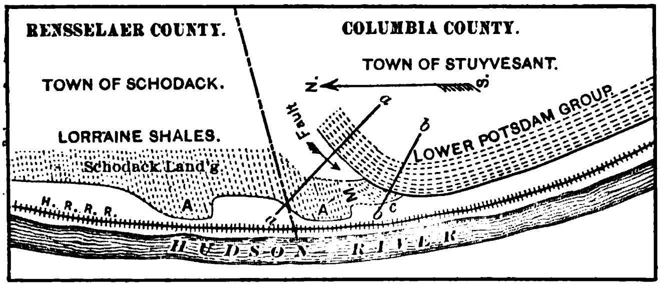
* Judging from the life-history of the Trilobite *Olenellus asaphoides*, as at present known, I should infer that the Troy and Stuyvesant Primordial beds are somewhat more recent than the Georgia slates; but there is not, to-day, so far as I am aware, any evidence that would warrant their separation from them as a distinct group, or their assignment to an independent geological horizon.

† I have rejected the designation "Hudson River Group," for the reasons (1) that the rocks of this group constitute, in all probability, but a small proportion of the terranes east of the Hudson river to which the name was originally and especially applied; (2) that the term, as a geographical one, has come to be misleading, as will be seen by the map of the Schodack region; and (3) that it has been the source of nearly or quite as much trouble in American geology as the term Taconic. The old synonym, "Lorraine," stands for a well-characterized

-ontories described in my former article. The rocks include shales and slates both fossiliferous and unfossiliferous; thick, gritty layers, one of which has afforded numerous specimens of *Orthis testudinaria* and *Leptæna sericea;* and one or more beds of limestone. Each of the promontories referred to contains a band of slates rich in graptolites, the best locality yet discovered occurring in promontory A, along the line of the Hudson River railroad, a few yards south of the flag-station at that point. Altogether this band has yielded fifteen species of graptolites, thirteen of which are well-known forms, and include *G. serratulus*, *G. divaricatus* and *G. Whitfieldi.* It has also furnished several specimens of a small *Lingula*, and an acephalous species probably identical with the *Lyrodesma pulchella* of Hall (Pal. N. Y., vol. i, p. 302, pl. 82, fig. 12). All of the beds have been greatly twisted and broken up, but their prevailing dip is eastward at high angles.



In its extension southward into Columbia county, the visible area of the Lorraine becomes somewhat contracted, and bears a little to the westward; and directly in front of Mr. Patrick McCabe's residence (M), it is completely cut off by a narrow marshy tract. Fifty yards south of Mr. McCabe's, however, a low ledge of similar rocks is met with, having a width at the northern extremity of a few rods, and a run to the southward of several hundred feet. The strike of the beds is a little east of north, the precise angle not determined. The slates of this ledge (*c*) have yielded the majority of the species of graptolites found in those of the promontories A and A′, and hence belong clearly to the same formation. At the date of publication of my former paper they had not been found fossiliferous.

Upon the southeast, the rocks of the ledge just described are immediately succeeded by a widely different group of strata, the fossils of which prove that they belong to the Primordial

group in Jefferson county, and has the advantage, in its application to rocks of the same age east of the Hudson river, of leaving the other formations which there occur uncompromised; and for these reasons, and these alone, I have been led to adopt it in my work.

zone. This group is represented upon the map by the obliquely lined area. A brief description of these older rocks, by the writer, is contained in the July number of this Journal, for 1884, and since that time I have been able to increase but little the already published list of species found in them. Some distance south of the most southerly reach of the Lorraine, the Primodial strata begin to run inland; and, continuing this, finally sweep past the point *c* in a broad, northeasterly-bearing curve. In one favored locality, the lower slates of this group are found reposing fairly upon those of the Lorraine; and upon the phenomena presented at this point, I propose now to speak.

The locality referred to is situated nearly due south of Mr. McCabe's residence, and, by pacing, 210 yards distant from it. It may be easily found by going directly across the low ground in front of the house to the ledge *c*, and then taking the by-road southward along the edge of the hill. This road is only a few rods distant from the Hudson River railroad track. A small spring issues from the slates directly on the line of contact of the two groups; and although, at first sight, the older slates appear to conform perfectly with the newer, a closer examination shows that their cut edges, owing to the curve of the beds, really make a small angle with them. Moreover, the slates of the two groups are lithologically different, those of the Lorraine being, for the most part, black and carbonaceous, and some of them graptolitic up to within a few inches of the line of the overlap; while those of the Primordial are unctuous and highly micaceous, or, as Professor Dana informs me, may be true hydromica schists. There can be no doubt of the existence here of a great physical break, the course of which is indicated upon the map, by the continuous line bounding the Primordial area upon its western side.

In order to make the leading structural features of the region under consideration still better understood, I give below two sections, one of them along the line *a a* of the map and the other along the line *b b*. In the first of these (fig. 1), the precise position of the fault is somewhat uncertain, but the known facts strongly suggest that its indicated position is a close approximation to the truth. This section passes a little to the northeast of Mr. Wood's residence, in the town of Stuyves-

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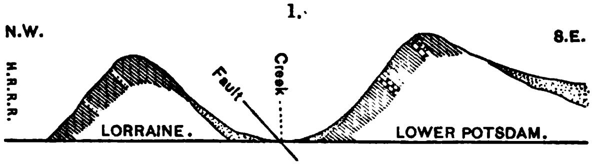
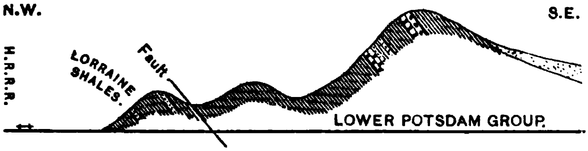


ant, in front of which, and all the way to the bottom of the ravine which it faces, the Lorraine beds are concealed by drift. The opposite slope is to some extent similarly mantled over; but the character of the underlying beds has been well ascertained.

2.



In the second section (fig. 2), the two groups are shown in contact with each other, and the fault is located with precision. Beyond this the section does not appear to me to call for special comment. On tracing the Primordial rocks eastward over the country, they are found to be arranged in a series of rather broad synclinal folds with apparently intervening denuded anticlinals. I have not yet attempted to trace out the course of the fault in its more eastward extension.

I have purposely dwelt at some length upon the structure of this remarkable region, partly because of the great interest which it possesses, and partly because of the efforts that have been put forth during the past two or three years, to banish from geology altogether what has, I believe, with good reason been denominated "The Great Appalachian Fault." These efforts have been grounded mainly upon the results of investigations conducted upon the west side of the Hudson river, and having no real bearing upon the question. One writer, in particular, whose views have appeared during the period referred to,* has pronounced the Great Appalachian Fault to be purely hypothetical, principally upon the strength of field-work done in the vicinity of Rondout; and a disposition seems to have sprung up in other minds, at about the same period, to advocate a similar view. To those who may have been led, either by their own investigations, or the researches of others, to so regard the matter, the region herein described is respectfully recommended, as one well calculated to conduct to the opposite conclusion.

Schodack Landing, N. Y., Oct. 30th, 1884.

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* Mr. W. M. Davis, on "The Non-conformity at Rondout, N. Y." This Journal for November, 1883.

ART. VI.—*On the Cause of Mild Polar Climates;* by JAMES CROLL, LL.D., F.R.S.*

THERE are few facts within the domain of geology better established than that at frequent periods in the past the polar regions enjoyed a comparatively mild and equable climate, and that places now buried under permanent snow and ice were then covered with a rich and luxuriant vegetation. Various theories have been advanced to account for this remarkable state of things, such as a different distribution of sea and land, a change in the obliquity of the ecliptic, a displacement in the position of the earth's axis of rotation, and so forth. The true explanation will, I feel persuaded, be found to be the one I gave many years ago. The steps by which the results were reached were as follows:

The annual quantity of heat received from the sun at the equator is to that at the poles as 12 to 4·98, or, say as 12 to 5. This on the supposition that the same percentage of rays is cut off by the atmosphere at the equator as at the poles, which, of course, is not the case. More is cut off at the poles than at the equator, and consequently the difference in the amount of heat received at the two places is actually greater than that indicated by the ratio 12 to 5. But, assuming 12 to 5 to be the ratio, the question arose what ought to be the *difference* of temperature between the two places in question on the supposition that the temperature was due solely to the direct heat received from the sun? This was a question difficult to answer, for its answer mainly depended upon two things, regarding both of which a very considerable amount of uncertainty prevailed.

First, it was necessary to know how much of the total amount of heat received by the earth was derived from the sun and how much from the stars and other sources, or in other words, from space. Absolute zero is considered to be 461° below zero, Fahr. The temperature of the equator is about 80°. This gives 541° as the absolute temperature of the equator. Now were all the heat received by the earth derived simply from the sun, and were the temperature of each place proportionate to the amount directly received, then the absolute temperature of the poles would be $\frac{5}{12}$ of that of the equator, or 225°. This would give a difference of 316° between the temperature of the equator and that of the poles. According to Pouillet and Herschel space has a temperature of −239°, or 222° of absolute temperature. If this be the temperature of space, then only 319° of the absolute temperature of the equator are derived from the sun; consequently as the poles receive from the sun only $\frac{5}{12}$ of this amount of temperature, or 133°, this will give merely 186° as the difference which ought to exist between the equator and the poles. There is, however, good reason for believing that the temperature of space is far less than that assigned by Pouillet and Herschel—that, in fact, it is probably not far above absolute zero. Therefore by adopting so high a temperature as —239°, we make the difference between the temperature of the equator and that of the poles too small.

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* From the Phil. Mag. for October, 1884.

Second, it was necessary to know at what rate the temperature increased or decreased with a given increase or decrease in the amount of heat received. It was well known that Newton's law—that the change of temperature was directly proportionate to the change in the quantity of heat received—was far from being correct. The formula of Dulong and Petit was found to give results pretty accurate within ordinary limits of temperature. But it would not have done, in making my estimate, to take that formula, if I adopted Herschel's estimate of the temperature of space; for it would have made the difference of temperature between the equator and the poles by far too small. Newton's law, if we adopt Herschel's estimate of the temperature of space, would give results much nearer the truth; for the error of the one would, to a large extent at least, neutralize that of the other.

From such uncertain data it was, of course, impossible to arrive at results which could in any way be regarded as accurate. But it so happens that perfect accuracy of results in the present case was not essential. All that really was required was a rough estimate of what the difference of temperature between the equator and the poles ought to be. The method adopted showed pretty clearly, however, that the difference of temperature could not be less (although probably more) than 200°. But the present actual difference does not probably exceed 80°. We have no means of ascertaining with certainty what the mean annual temperature of the poles is; but as the temperature of latitude 80° N. is 4°·5, that of the poles is probably not under 0°. If the present difference be 80°, it is then 120° less than it would be did the temperature of each place depend alone on the heat received directly from the sun. This great reduction from about 200° to 80° can, of course, be due to no other cause than to a transference of heat from the equator to the poles. The question then arose, by what means was this transference effected? There were only two agencies available—the transference must be effected either by aerial or by ocean currents. It was shown at considerable length (Climate and Time, pp. 27–30, and other places) that the amount of heat that can be conveyed from the equator to the poles by means of aerial currents is trifling, and that, consequently, the transference must be referred to the currents of the ocean. It became obvious then that the influence of ocean-currrents in the distribution of heat over the globe had been enormously under-estimated. In order to ascertain with greater certainty that such had been the case, I resolved on determining, if possible, in absolute measure the amount of heat actually being conveyed from the equator to temperate and polar regions by means of ocean-currents.

The only great current whose volume and temperature had been ascertained with any degree of certainty was the Gulf-stream. On computing the absolute amount of heat conveyed by that stream, it was found to be more than equal to all the heat received from the sun within 32 miles on each side of the equator. The amount of equatorial heat carried into temperate and polar regions by this stream alone is therefore equal to one-fourth of all the heat received from the sun by the North Atlantic from the tropic of Cancer up to the Arctic Circle.* Although the heating power of the Gulf-stream had long been known, yet no one had imagined that the warmth of our climate was due, to such an enormous extent, to the heat conveyed by that stream. The amount of heat received by an equatorial zone 64 miles in breadth represents, be it observed, merely the amount conveyed by one current alone. There are several other great currents some of which convey as much heat polewards as the Gulf-stream. On taking into account the influence of the whole system of oceanic circulation, it was not surprising that the difference of temperature between the equator and the poles should be reduced from 200° to 80°.

From these considerations, the real cause of former comparatively mild climates in Arctic regions became now apparent. All that was necessary to confer on, say Greenland, a condition of climate which would admit of the growth of a luxuriant vegetation was simply an increase in the amount of heat transferred from equatorial to Arctic regions by means of ocean-currents. And to effect this change of climate, no very great amount of increase was really required; for it was shown that the severity of the climate of that region was about as much due to the cooling effect of the permanent snow and ice as to an actual want of heat. An increase in the amount of warm water entering the Arctic Ocean, just sufficient to prevent the formation of permanent ice, was all that was really necessary; for were it not for the presence of ice the summers of Greenland would be as warm as those of England.

Were the whole of the warm water of the Gulf-stream at present to flow into the Arctic Ocean, it would probably remove the ice of Greenland. Any physical changes, such as those that have been discussed on former occasions, which would greatly increase the volume and temperature of the stream and deflect more of its waters into the Arctic Ocean would, there is little doubt, confer on the polar regions a climate suitable for plant and animal life. At present the Gulf-stream bifurcates in mid-Atlantic, one branch passing northeastward into the Arctic regions, whilst the larger branch turns southeastward by the Azores, and after passing the Canaries re-enters the equatorial current. As the Gulf-stream, like other great currents of the ocean, follows almost exactly the path of the prevailing winds,* it bifurcates in mid-Atlantic simply because the winds blowing over it bifurcate also. Any physical change which would prevent this bifurcation of the winds and cause them to blow northeastward would probably impel the whole of the Gulf-stream waters into the Arctic seas. All this doubtless might quite well be effected without any geographical changes, although changes in the physical geography of the North Atlantic might be helpful.

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* Climate and Time, pp. 34. 35; Phil. Mag., February, 1870.

These considerations regarding the influence of the Gulf-stream point to another result of an opposite character. It is this: if a large *increase* in the volume and temperature of the stream would confer on Greenland and the Arctic regions a condition of climate somewhat like that of Northwestern Europe, it is obvious, as has been shown at length on former occasions, that a large *decrease* in its temperature and volume would, on the other hand, lead to a state of things in Northwestern Europe approaching to that which now prevails in Greenland. A decrease leads to a glacial, an increase to an inter-glacial condition of things.

Sir William Thomson on Mild Arctic Climates.—In a paper read before the Geological Society of Glasgow in February, 1877, Sir William maintains also that an increase in the amount of heat conveyed by ocean-currents to the Arctic regions, combined with the effect of Clouds, Wind, and Aqueous Vapor, is perfectly sufficient to account for the warm and temperate condition of climate which is known to have prevailed in those regions during former epochs. The following quotations will show Sir William's views:—

> "A thousand feet of depression would submerge the continents of Europe, Asia and America, for thousands of miles from their present northern coast-lines, and would give instead of the present land-locked, and therefore ice-bound Arctic sea, an open iceless ocean, with only a number of small steep islands to obstruct the free interchange of water between the North Pole and temperate or tropical regions. That the Arctic sea would, in such circum-

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* See 'Climate and Time,' p. 213.

stances, be free from ice quite up to the north pole may be, I think, securely inferred from what, in the present condition of the globe, we know of ice-bound and open seas in the northern hemisphere and of the southern ocean abounding in icebergs, but probably nowhere ice-bound up to the very coast of the circumpolar Antarctic continent, except in more or less land-locked bays." . . . .

"Suppose now the sea, unobstructed by land from either pole to temperate or tropical regions, to be iceless at any time, would it continue iceless during the whole of the sunless polar winter? *Yes*, we may safely answer. Supposing the depth of the sea to be not less than 50 or 100 fathoms, and judging from what we know for certain of ocean currents, we may safely say that differences of specific gravity of the water produced by difference of temperature not reaching any where down to the freezing point, would cause enough of circulation of water between the polar and temperate or tropical regions to supply all the heat radiated from the water within the Artic circle during the sunless winter, if air contributed none of it. Just think of a current of three quarters of a nautical mile per hour, or 70 miles per four days, flowing towards the pole across the Arctic circle. The area of the Arctic circle is 700 square miles for each mile of its circumference. Hence 40 fathoms deep of such a current would carry in, per twenty-four hours, a little more than water enough to cover the whole area to a depth of 1 fathom; and this, if 7·1° Cent. above the freezing point, would bring in just enough of heat to prevent freezing, if in twenty-four hours as much heat were radiated away as taken from a tenth of a fathom of ice-cold water would leave it ice at the freezing point. This is no doubt much more than the actual amount of radiation, and the supposed current is probably much less than it would be if the water were ice-cold at the pole and 7° Cent. at the Arctic circle. Hence, without any assistance from air, we find in the convection of heat by water alone, a sufficiently powerful influence to prevent any freezing up in polar regions at any time of year."—*Trans. of the Geol. Soc. of Glasgow*, 22d February, 1877.

That an amount of warm water flowing into the Arctic Ocean equal to that assumed by Sir William Thomson, along with the effects of clouds, wind, dew, and other agencies to which he refers would wholly prevent the existence of permanent ice in those regions, is a conclusion which, I think, can hardly be doubted. It is with the greatest deference that I venture to differ from so eminent a physicist; but I am unable to believe that such a transference of water from intertropical and temperate regions could be effected by the agency to which he attributes it. Certainly the amount of heat conveyed by means of a circulation resulting from difference of specific gravity, produced by difference of temperature, must be trifling when compared with that of ocean-currents produced by the impelling force of the winds. Take, for example, the case of the Gulf-stream. If the amount of heat conveyed from intertropical regions into the North Atlantic by means of difference of density resulting from difference of temperature were equal to that conveyed by the Gulf-stream, it would follow, as has been proved,* that the Atlantic would be far warmer in temperate and arctic than in intertropical regions. Taking the annual quantity of heat received from the sun per unit surface at the equator as 1,000, the quantities received by the three zones would be respectively as follows:—

Equator	1000
Torrid zone	975
Temperate zone	757
Frigid zone	454

Assume, then, that as much heat is conveyed from intertropical regions into the Atlantic and Arctic seas by this circulation from difference of specific gravity as by the Gulf-stream, and assume also that one half of the total heat conveyed by the two systems of circulation goes to warm the Arctic Ocean, and the other half remains in temperate regions, the following would then be the relative quantities of heat possessed by the three zones:—

Atlantic in torrid zone	671
" in temperate zone	940
" in frigid zone	766

There is a still more formidable objection to the theory. It has been demonstrated, from the temperature-soundings made by the "Challenger' Expedition,† that the general surface of the North Atlantic must, in order to produce equilibrium, stand at a higher level than at the equator. In other words, the surface of the Atlantic is lowest at the equator, and rises with a gentle slope to well nigh the latitude of England. This curious condition of things is owing to the fact that, in consequence of the enormous quantity of warm water from intertropical regions which is being continually carried by the Gulf-stream into temperate regions, the mean temperature of the Atlantic water, considered from its surface to the bottom is greater, and the specific gravity less, in temperate regions than at the equator. In consequence of this difference of specific gravity, the surface of the Atlantic at latitude 23° N. must stand 2 feet 3 inches above the level of the equator, and at latitude 38° N. 3 feet 3 inches above the equator. In this case it is absolutely impossible that there can be a flow in the Atlantic from the equatorial to the temperate regions resulting from difference of specific gravity. If there is any motion of the water from that cause, it must, in so far as the Atlantic is concerned, be in the very opposite direction, viz: from the temperate to the equatorial regions.

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* 'Climate and Time,' Chap. xi; Phil. Mag., March, 1874.

† 'Climate and Time,' pp. 220–225; Phil. Mag., September and December, 1875; 'Nature,' November 25th, 1875.

All, or almost all, the heat which the Arctic seas receive from intertropical regions in the form of warm water comes from the Atlantic, and not from the Pacific; for the amount of warm water entering by Behring Strait must be comparatively small. It therefore follows from the foregoing considerations that none of that equatorial heat can be conveyed by a circulation resulting from difference of specific gravity produced by difference of temperature.

It is assumed as a condition in this theory that a submergence of the Arctic land of several hundred feet must have taken place in order to convert that land into a series of islands allowing of the free passage of water round them. But the evidence of geology, as was shown on a former occasion,* is not altogether favorable to the idea that those warm climates were in any way the result of a submergence of the polar land. Take the Miocene epoch as an example, all the way from Ireland and the Western Isles, by the Faroes, Iceland, Franz-Joseph Land, to North Greenland, the Miocene vegetation and the denuded fragmentary state of the strata point to a much wider distribution of Polar land than that which now obtains in those regions.

Mr. Alfred R. Wallace on mild Arctic Climates.—The theory that the mild climates of Arctic regions were due to an inflow of warm water from intertropical and temperate regions has also been fully adopted by Mr. Alfred R. Wallace. But, unlike Sir William Thomson, he does not attribute this transference of warm water to a circulation resulting from difference of density produced by difference of temperature, but to currents caused by the impelling force of the wind.

Mr. Wallace shares in the opinion now entertained by a vast number of geologists that during the whole of the Tertiary period the climate of the north temperate and polar regions was uniformly warm and mild, without a trace of any intervening epochs of cold. According to him there were no glacial or interglacial periods during Tertiary times. In this case he, of course, does not suppose that the inflow of warm water into Arctic regions, on which the mild condition of climate depended, was in any way due to those physical agencies which came into operation during an interglacial period. Mr. Wallace accounts for the mild Arctic climate during the Tertiary period by the supposition that at that time there were probably several channels extending from equatorial to arctic regions through the eastern and western continents, allowing of a continuous flow of intertropical water into the Arctic Ocean. Mr. Wallace expresses his views on the point thus:—

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* Geol. Mag., September, 1878.

> "The distribution of the Eocene and Miocene formations shows that during a considerable portion of the Tertiary period an inland sea, more or less occupied by an archipelago of islands, extended across Central Europe between the Baltic and the Black and Caspian Seas, and thence by narrower channels southeastward to the valley of the Euphrates and the Persian Gulf, thus opening a communication between the North Atlantic and the Indian Ocean. From the Caspian also a wide arm of the sea extended during some part of the Tertiary epoch northwards to the Arctic Ocean; and there is nothing to show that this sea may not have been in existence during the whole Tertiary period. Another channel probably existed over Egypt into the eastern basin of the Mediterranean and the Black Sea; while it is probable that there was a communication between the Baltic and the White Sea, leaving Scandinavia as an extensive island. Turning to India, we find that an arm of the sea of great width and depth extended from the Bay of Bengal to the mouths of the Indus; while the enormous depression indicated by the presence of marine fossils of Eocene age at a height of 16,500 feet in Western Tibet renders it not improbable that a more direct channel across Afghanistan may have opened a communication between the West-Asiatic and Polar seas."—('*Island Life,*' p. 184.)

My acquaintance with the Tertiary formations of the globe, and with the distribution of land and water during that period, is not such as to enable me to form any opinion whatever either as to the probability or to the improbability of the existence of such channels as are assumed by Mr. Wallace. But, looking at the question from a physical point of view, it seems to me pretty evident that if such channels as he supposes existed, allowing of a continuous flow of equatorial water into the Arctic seas, it would certainly prevent the formation of permanent ice around the pole, and would doubtless confer on the arctic regions a mild and equable climate. This would be more particularly the case if, as Mr. Wallace supposes, owing to geographical conditions, far more of the equatorial water was deflected into the arctic than into the antarctic regions.

But at the same time I think it is just as evident that these channels would not neutralize the effects resulting from a high state of eccentricity. It may be quite true that the physical cause brought into operation during a high state of eccentricity might not be sufficient to reduce the quantity of warm water flowing into the Arctic Ocean to an extent that would permit of the formation of permanent ice around the pole, but it certainly would greatly diminish the flow into the Arctic Ocean. Supposing that at the commencement of the last Glacial epoch the volume of the Gulf-stream to have been double what it is at present; this condition of things would not have prevented the operation of these physical agents which brought about the Glacial epoch, although it, no doubt, would have considerably modified the severity of the glaciation resulting from their operation. The very same thing would hold true, though perhaps in a much greater degree in reference to the channels assumed by Mr. Wallace.

If the emissive power of the sun was about the same during the Tertiary period as at present, and there is no good grounds for supposing it was otherwise, then the extra heat possessed by the northern temperate and arctic regions must have been derived either from the equatorial regions or from the southern hemisphere, or, what is more likely, from both. If so, then the temperature either of the southern hemisphere or of the intertropical regions, or both, must have been during the Tertiary period much lower than at the present day. A lowering of the temperature of the equatorial regions, resulting from this transference of heat, would tend to produce a more equable and uniform condition of climate over the whole of the northern hemisphere. As the area of the Arctic Ocean is small in comparison to that of the equatorial zone, from which the warm water was derived, the fall of temperature at the equator would be much less than the rise at the pole. Supposing there had been a rise of say 30° at the pole resulting from a fall of 10° at the equator (and this is by no means an improbable assumption), this would reduce the difference between the equator and the pole by 40°, or to half its present amount. We should then have a climatic condition pretty much resembling that which is known to have prevailed during at least considerable portions of the Tertiary period.

It is indeed very doubtful if such a climatic condition of things as that could be brought about by a high state of eccentricity with the present distribution of land and water; but, on the other hand, it is just as doubtful whether the channels of communication assumed by Mr. Wallace could have brought it about without the aid of eccentricity.

The very existence of so high a temperature on the northern hemisphere during Tertiary times may be regarded as strong presumptive proof that the geographical conditions obtaining on the southern hemisphere were most unfavorable to the flow of intertropical water into that hemisphere. This may be one of the reasons why a high state of eccentricity failed to produce a well-marked glacial epoch on the northern hemisphere, the geographical conditions preventing a transference of warm water into the southern hemisphere sufficient to produce true glaciation on the opposite hemisphere. That the geographical conditions obtaining on the southern hemisphere during Tertiary times were probably of such a character is an opinion advanced by Mr. Wallace himself. "There are," he says, "many peculiarities in the distribution of plants and of some groups of animals in the southern hemisphere, which render it almost certain that there has sometimes been a greater extension of the antarctic lands during Tertiary times; and it is therefore not improbable that a more or less glaciated condition may have been a long-persistent feature of the southern hemisphere, due to the peculiar distribution of land and sea, which favors the production of ice-fields and glaciers." (p. 192.)

[To be continued.]

ART. VII.—*An attempt to determine the Amount and Rate of Chemical Erosion taking place in the Limestone* (*Calciferous to Trenton*) *Valley of Center County, Pa., and hence applicable to similar regions throughout the Appalachian Regions;* by A. L. EWING.

IN the following, the nature of the problem precludes the idea of even a close approximation to accuracy. It is claimed however that these determinations form a more reliable basis than mere estimates.

The method pursued is as follows: The amount of water flowing from a given hydrographic basin in the region under question is determined from the cross-section and velocity of the stream draining it. The amount of solids in the water is determined by evaporation; these data with the area of the basin form the basis of calculation.

The region selected is that of the Spring Creek basin which forms a considerable portion of the limestone valley of Center County. The measurements were made above the old dam below Bellefonte and below the entrance of all visible tributaries from the valley.

That a fair conception of the region may be had a brief explanation of its geology is necessary. The region under consideration forms a part of Nittany Valley. This valley, known under different names, extends through a considerable portion of the Appalachian region, and consists of the remains of a great anticlinal fold, which had it not been worn down would form an immense mountain-like plateau over 20,000 feet above its present height. As it is, the floor of the valley consists of the upturned edges of the lower Silurian limestone eroded through a thickness of 6,000 feet. The valley is flanked on either side by the remnants of the overlying Medina Sandstone which forms monoclinal ridges from 600 to 1,000 feet above its floor. The inside slopes of these mountains are formed by the Utica and Hudson River shales.

The great amount of erosion that has taken place here is an interesting geological topic. That in early times it was mainly mechanical, caused by the steeper declivities, is undoubtedly true. The present topographical features, however, can not be explained without considering the excessive chemical erosion of the limestone. This I believe is the opinion of the geologists who have visited the region. The water from the limestone contains a large amount of calcium and magnesium salts. That from the State College well gives ·2273 grams per liter of solids, over 80 per cent of which are calcium and magnesium carbonates. Sink holes, caves, etc., are common as in other limestone regions. Still, I am not aware that any attempts have been made to determine the *amount of erosion* taking place by this process, and hence the following is submitted.

Average width of stream where the measurements were taken, 22·86 meters (75 ft.). Depth, average of six measurements across the bed of the stream, ·823 meters (2·7 ft.). This gives as the cross-section of the stream 18·81m^2 (202·5 sq. ft.). Allowance was made in these determinations for obstruction from weeds, etc.

The velocity of the stream was determined by floating surface particles and by floating a long bottle weighted with shot at various depths from ·3 m. to ·75 m. (the greatest depth of the stream being 1m.). The velocity of the stream was found to be 994·776 m. per hour, this giving 18·172m^3, as the amount of water removed per hour. The water shows on evaporation, as average of two tests, 155·3 grams per m^3, giving 2,905,974 grams the amount of solids removed per hour, or 25,456,560 kilos. per annum. As the area of limestone drained by Spring Creek is about 100 sq. miles, this gives 255·654 kilos. of solids as the amount removed per annum per sq. mile. This is equivalent to 282 tons.

A portion of the water carried off by Spring Creek, however, falls not upon the limestone area considered above, but upon the mountains bordering the valley. Probably one-fourth of the water falls upon the mountains. To show that the main part of the solids comes from the limestone, I had specimens of the water as it flows from the mountains evaporated. An average of two tests gave 16·5 grams per m^3, or a little over one-tenth of the amount found in the water as it flows from the valley. Thus not more than one-fortieth of the solids in the Spring Creek *water* probably comes from the mountains.

Making this correction it still leaves 275 tons per sq. mile as the amount annually removed in solution.

A closer approximation could be made by continuing observations similar to the above through a period of time, say for one year. To get the *amount of water* carried off in a year this would be necessary. Yet it is evident that the *amount of solids carried away in solution is much more constant than the amount of water flowing through the stream;* as in times of freshet or excessive flow there is a larger proportion of surface water, while in times of diminished flow a relatively larger portion of the water reaches the stream through underground drainage and must contain more solids. Hence the above number, 275 tons per sq. mile, may be taken as a fair approximation to the amount of material actually removed per annum in this and similar regions.

According to the above determinations and assuming that the solids removed have a specific gravity of 2·8, we get as the cubic contents of the mass removed from the entire basin 9,130·5m^3, or 91·3m^3 per sq. mile per annum, making the deduction as before of one-fortieth for the amount brought from the mountains; and conceiving the remainder to be spread evenly over the surface it would form a layer $\frac{1}{29173}$ of a meter in thickness. Hence to lower the surface to the extent of 1 m. by this process would require 29,173 years, or about 9,000 years to remove one foot from the surface.

It is safe to assume that had the rocks of this region been similar to those of the bordering mountains in their nature and power to resist dynamical agencies we should have in place of Nittany valley a mild anticlinal plateau somewhat above the mountains in elevation, say 1000 feet above the present height of the valley. The erosion in the valley then in excess of that along the mountains has been mainly chemical and at least 1000 feet of limestone has been thus removed. A simple further deduction shows that accordingly Nittany valley has been 1,000,000 years in process of formation.

The *limestone erosion* could not begin before the latter stages of the Mesozoic era, possibly not before the Cenozoic era, as sufficient time must have elapsed subsequent to the Carboniferous age to erode all formations of the Paleozoic era above the Trenton limestones. One million years seems not inconsistent with other estimates of geological time; still these calculations respecting time are an afterthought and supplementary to the main point intended to be shown in this paper, viz: the rate and amount of chemical erosion of limestone.

Art. VIII.—*On the Chrysotile from Shipton, Canada;* by Erastus G. Smith, Ph.D.

There has recently come into my possession, through the kindness of Mr. W. H. Jeffreys of Richmond, several specimens of the fibrous variety of serpentine or chrysotile from the above named locality. So well characterized were the specimens, and diligent search failing to discover any analyses or description of the properties of the mineral from this locality, an examination was instituted with results appended below.

Serpentine is commonly met with through many portions of the Province of Quebec, occurring either as large deposits of the comparatively pure mineral or more generally mixed with other minerals, notably calcite and chromite. Chromite especially appears to be almost always present in the serpentine of the Silurian rocks.

The fibrous variety of serpentine or chrysotile generally spoken of as "asbestus," appears to be distributed also in almost unlimited quantities through many of the southeastern townships, notably at Thetford and Coleraine. (See Report of Geological Survey of Canada, 1881–82, G.G., pp. 6–8).

The chrysotile from Shipton seems to be of much the same character both in appearance and mode of occurrence. It occurs in narrow veins of from one to four inches in width traversing the solid serpentine. These veins possess little or no regularity, often abruptly terminating. The fibers run transversely, improving in quality as the mineral recedes from the surface of the ground. In appearance the chrysotile has a fine silky luster, varying in color from a deep green to a pale yellow. The fibers can be easily separated from each other, forming a soft voluminous wool-like mass. Before the blow-pipe it is fusible only with the very finest fibers. It yields water readily on ignition, being at first blackened and finally assuming a dull brown color. The ignited mass loses its fibrous character and crumbles easily beneath the fingers. The reaction for iron is always marked and *with some specimens that for chromium also*, though as will be noticed, the particular specimens analyzed gave *no* chromium reaction. This variable reaction is accounted for by the fugitive presence of chromite in the vicinity, which as already noted, so often accompanies the Canada serpentines.

Two specimens were selected for analysis: I. Dark green, sp. gr. 2·142 (temp. 16° C.). II. Pale yellow, sp. gr. 2·286 (temp. 16° C.).

	I.	II.
SiO_2	41·837	42·043
FeO	2·234	3·663
MgO	41·990	39·540
H_2O	14·282	14·309
	100·343	99·555

These analyses establish clearly the identity of this mineral with the chrysotile from other localities, as can be readily confirmed by comparing them with the analyses already published.

Chemical Laboratory of Beloit College, Beloit, Wisconsin, Nov. 28, 1884.

ART. IX.—*The Santa Catharina Meteorite;* by ORVILLE A. DERBY.

HAVING recently undertaken, in company with Mr. Luiz Gonzaga de Campos, an examination of the Brazilian meteorites preserved in the National Museum of Rio de Janeiro, in which that gentleman has taken charge of the chemical and I of the physical part of the work, I have had occasion to make the following observations on the somewhat famous Santa Catharina meteorite which seem to be of sufficient importance to warrant publication in advance of the more extended general memoir that we are now preparing.

M. Daubrée, who has so thoroughly studied the metallic portion of this meteorite, mentions an ochreous crust in some of the specimens* which he took to be of secondary and terrestrial origin, and to be composed of a mass of limonite resulting from the oxidation of the iron, together with imprisoned fragments of the disintegrated granite on which the mass was stated to have rested. Misled by this conclusion (a very natural one if, as is to be presumed, the crust on the specimens examined was partially decomposed), he devoted all his attention to the metallic elements with the brilliant results that are so well known. This crust, however, when examined on well preserved specimens, proves to be an essential part of the meteorite, in nothing inferior in interest to the metallic portion. Aside from the many interesting points of structure it presents in itself, it affords the best of proofs that the mass is really of meteoric origin, a matter which the peculiar properties of the iron had placed in doubt. Moreover, it appears to indicate the existence of a new group of meteorites intermediate in character between the holosiderites (composed wholly of iron) and the syssiderites (with stony portions disseminated in a spongy metallic mass) of Daubrée, or perhaps rather it should be said that it throws new light on the real structure of the former.

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* Comptes Rendus, vol. lxxxiv, p. 1508. Études synthétiques de Géologie Expérimentale, p. 536.

This crust has been observed in two forms, which, from the aspect presented macroscopically, may be called provisionally, the granitoid and the porphyritic. Although the former has not, like the latter, been observed adherent to the iron, it is evidently the primitive form and will be described first. It consists essentially of olivine in small glassy crystalline fragments and of plagioclase feldspar (apparently anorthite) in grains up to 6 or 8 millimeters in diameter. It is traversed by fine veinlets of black limonite which has also stained the mass red so that it presents the appearance of ordinary half decomposed granite. Under the microscope it has the aspect of a porphyry, the clear grains of olivine and such of the plagioclase as has escaped decomposition standing out brilliantly in a dark opaque groundmass consisting of limonite and of decomposed feldspar, and perhaps also of other decomposed silicates and of an original glassy groundmass, if the rock contained them. The olivine grains are beautifully clear but much fractured, showing along the cracks a yellow discoloration which occasionally presents a beautiful botryoidal appearance. The specimens of this rock have unfortunately been hammer-dressed, so that they show nothing of the original surface. They represent, however, a thickness of several centimeters at least. No grains of metallic iron have thus far been detected in them, but as points of the rock exert a slight influence on the magnetic needle, their presence is suspected. Minute grains that appear to be magnetite have been separated with the magnet, but have not yet been examined. The porphyritic rock forms a crust, 1 to 2 centimeters thick, completely enveloping an oblong rounded mass of iron, 18 centimeters long and 10 centimeters in diameter. This crust scales off readily, taking always a portion of the iron with it. Small fragments of iron are also scattered through it. The surface of this crust being somewhat decomposed and ochreous, the appearance of the entire mass, which may be called a meteoric individual, as it has evidently not been broken from a larger mass since the fall, is that of the concretionary masses of limonite common in decomposed granite and elsewhere. This is a true porphyry consisting of grains of olivine with rare fragments of plagioclase scattered in a dark glassy groundmass which can only with difficulty be rendered transparent, when it presents a light reddish color. The mass is somewhat scoriaceous from the presence of numerous rounded cavities, and the glass presents a fluidal structure. The feldspar has much the same appearance as in the granitoid form, that is to say, a clear nucleus surrounded by an opaque portion. The nucleus, however, is not troubled as in that rock, and the opacity is, in this case, evidently due to vitrification of the margins of the grain, and not to decomposition as in the case of the granitic rock.

In order to verify the idea that was at once suggested, that this porphyritic rock was the result of the partial fusion of the granitoid, I attempted to reproduce the peculiarities it presents. Taking quartz to represent the infusible element and labradorite for the fusible, I made a mixture of these minerals broken into small fragments, but not ground, adding some scraps of iron turnings and fragments of magnetic pyrites. After an incomplete fusion, the characters above mentioned were found to be very satisfactorily reproduced. The principal differences noted were that the glass was clearer and that those grains of feldspar which escaped complete vitrification were, for the most part, more troubled, many of them becoming quite opaque and with an abundant development of microlites.

It appears therefore that this meteorite presents a mixture of metallic and siliceous elements combined in a way that has not hitherto been noticed, and that the stony portion also presents a new type of structure in which olivine and plagioclase are the predominant elements. The partial vitrification of the stony portion seems to afford unequivocal evidence of the meteoric origin of the mass. The presence of silicates, in part fusible, which would form a crust of low conducting power about the iron will enable us to account satisfactorily for the low magnetism of portions of the mass noted by Lawrence Smith and Becquerel,* which led them to infer that the iron had crystallized below a red heat, a fact which it would be difficult to reconcile with the incandescence of meteorites, if the mass had been composed exclusively of metal. It may be reasonably inferred that different portions of the mass will be found to vary in magnetic properties. It is hoped that material for investigating this and other questions may be obtained in a visit which Mr. Campos will shortly make to the place of fall for the purpose of collecting facts for the full history of this interesting meteorite.

The observations here presented suggest the suspicion that other large iron meteorites may present something analogous, and it is hoped that an opportunity may shortly be afforded for examining the famous Bemdego meteorite which, judging from the descriptions of Mornay and of Spix, and Martius, contains stony portions. The former mentions a crust on the lower portion, and the latter state that it rested on a mass of granite fragments, which, in view of the above facts, may be suspected to have belonged to it. Both mention masses of quartz embedded in the iron which are most probably of olivine.

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* Comptes Rendus, vol. xciii, p. 794, 1881. This Journal, March, 1882.

ART. X.—*The Gravels of the Southern Delaware Peninsula;* by FREDERICK D. CHESTER.

IN a former number of this Journal (March, 1884), under the title of "*The Quaternary Gravels of Northern Delaware and Eastern Maryland,*" the writer described those deposits known as the Red Sand and the Philadelphia Brick Clay, which cover to great depths the underlying formations of New Castle and Cecil Counties. Later investigations in connection with a geological survey of Delaware lead us to consider the surface deposits of the peninsula as a whole; and, although this paper is intended as a continuation of the other, it will be necessary, first, to review very briefly some of the facts previously brought out, before describing in detail the phenomena of the southern area. The surface formations of the peninsula may be classed as follows:

1.	High Level or Bryn Mawr Gravel		Cretaceous?
2.	Delaware Gravels	Red Sand. Philadelphia Brick Clay.	Quaternary.
3.	Estuary Sands		Quaternary.
4.	Bog Clay		Modern.

A REVIEW OF THE NORTHERN AREA.

High Level Gravels.—In traveling over the highlands of Northern Delaware, just back of the old terrace line of the succeeding Post-Glacial formation, one is liable to come upon solitary patches of gravel, varying in area from a few hundred square feet to several acres. They do not always form strata of definite depth, but often the rounded pebbles are found mixed with a predominating quantity of angular material, *in situ*, while again, in other places, a well defined deposit may be traced, as in the northeast part of the State, over a large area of several square miles. The gravel is made of highly waterworn quartzose and quartzitic pebbles, associated with a considerable amount of ferruginous grit and conglomerate.

As regards the position and extent of these isolated patches, there seems to be no law, but capping as they do the highest points of the hills, which rise from 350 to 400 feet above tide water, it is probable that they represent the remnants of a once continuous patch. The same formation, as shown by other geologists, extends over the heights of Southeastern Pennsylvania, Southern New Jersey, and the District of Columbia, indicating a considerable ingress of the sea shore line. As far as Delaware is concerned, we can say, that during the Bryn

Mawr period the State was submerged to a great depth, probably much greater than the maximum limits in Delaware indicate. The exact outline of this old sea, extending far within the bounds of other States must be traced, as it will be, by the work of the several geologists engaged upon this particular field, and the results will be eagerly looked for.

The question of the age of the High Level Gravels is one of much interest. The extreme erosion which they have suffered, that isolated patches might be produced, is alone sufficient proof of their great age. If they once formed a continuous layer, covering the tilted Archæan rocks, thew hole topography of that area must have been produced since their deposition—the depth of erosion in Delaware amounting to a maximum of 300 feet. Prof. W. M. Fontaine has described * a similar gravel found covering the Azoic areas of Virginia. It occurs as solitary patches along the western margin of all the interior belts of the Mesozoic, the materials being bowlders and conglomerates of the Potsdam, Azoic and Mesozoic rocks, imbedded in a stiff clay. That these patches represent the eroded edges of Mesozoic strata, would be gathered from Professor Fontaine's statements. The origin of the materials, particularly the large bowlders, is supposed to be from glaciers descending the eastern slopes of the Alleghanies in later Jurassic time. The same gravel is said by Professor Fontaine to extend as far north as the heights around Washington, where it is known to be contemporaneous with the high level gravel of Delaware and Southeastern Pennsylvania. Thus we have one continuous line of gravel patches bordering the western edge of the Mesozoic and extending from Virginia to New Jersey. The careful labors of Mr. W. J. McGee of the U. S. Geological Survey upon the High Level Gravels in the neighborhood of Washington are quite in accordance with the view of their late Jurassic or Lower Cretaceous age, although the writer does not feel at liberty to make any special use of Mr. McGee's results previous to their publication.

Mr. C. E. Hall in his Report on Southeastern Pennsylvania has expressed the view that the Mesozoic strata lying to the southeast once extended far to the northwest, so as to overlie the Azoic, and that these isolated patches may represent the remnants of this former extension. Thus far I think, that in absence of direct evidence regarding the age of the gravels we are led to regard them as more probably of late Jurassic or early Cretaceous.

Considering again the great erosion which the High Level Gravels have suffered, it is interesting to enquire into what has become of the portion removed. No doubt it has suffered re-

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* Mesozoic Strata of Virginia. This Journal, III, vol. xvii, p. 31.

deposition by the waters of succeeding time. The writer has consequently looked throughout the Tertiary for evidence bearing upon this point, and has been to some degree successful. From numerous records of well-diggings, it is found that fragments of similar grit, called by the people "iron ore," are seen in the white Tertiary sand, but whether they are re-deposited Bryn Mawr is a point upon which the utmost confidence cannot as yet be placed. Yet the abundance of well rounded fragments of conglomerate everywhere throughout the Delaware Gravels points in numerous cases to indisputable Bryn Mawr origin. The great difficulty, however, in the way of recognizing such identity is their confusion with similar fragments formed at present by the action of ferruginous waters upon sand and pebbles, but particularly by the segregation of crusts within the substance of quartzitic bowlders. Notwithstanding these difficulties there can be little doubt but that many of the representatives of the Delaware Gravels had their source in the older High Level formation.

Delaware Gravels.—Passing along the slope of the old Azoic hills, which trend in a northeast and southwest direction, between the Delaware and the Susquehanna rivers, a distinct terrace line can be traced, rising upon an average of 200 feet above the river, but increasing in its altitude toward the west and presenting throughout its entire length a more or less ragged outline, due to the subsequent decay of the hill-slopes upon which it rests. This shore line marked, as we know, the head of a Post-glacial estuary, into which the swollen Delaware poured its mass of *debris.* The deposit thus made, purely fluviatile in origin, yet spread over an estuary floor, we have called the *Delaware gravels.* It consists, as we have seen, of an upper layer of brick clay containing in most cases a large amount of fine and coarse gravel, cobble stones, and bowlders, with many features characteristic of the bowlder clay and having a uniform thickness of from two to three feet. Beneath this is a thick stratum of highly ferruginous sand and gravel, exhibiting eminent stratification, with oblique laminations, or flow-and-plunge structure, having an average depth of twenty-five feet. These *Delaware gravels* are spread out from the shore-line over all the northern part of the peninsula, of which a detailed description has already been given.

Bog Clay.—By passing up and down the Delaware River, one notices at a variable distance of from one-quarter to a couple of miles, a low terrace, having an altitude above the river of from twenty to thirty feet. Its course is usually very winding, sometimes bending almost to the river, and again extending far inland and winding around so as to form broad and deep enclosures. This secondary terrace line is but an abrupt termination of the rolling gravels extending down from the upland terrace. It marks the last stage in the retreat of the estuary waters. Beneath this lowest terrace and that terrace some 200 feet higher up and several miles to the north, are traced a number of indistinct intermediate terrace lines. One of these, rising some sixty feet above the river, can be followed from Wilmington for twenty miles or more to the south, keeping for the greater portion of its length the course of the Delaware railroad. From the lowest river terrace of red gravel, the same deposit is seen to dip beneath a uniform bed of black clay, and is always struck in the digging of deep drainage trenches along the shore. A deposition of the same bog clay is now going on by means of flood-tide, whenever the land is unprotected by earth dikes. It is this impervious layer which forms the basis of all the undrained marsh land of the river and bay shore.

PHENOMENA OF THE SOUTHERN AREA.

General considerations. — Beginning with the latitude of Appoquinimink Creek, which marks the southern boundary of New Castle County, Del., and extending to the lowermost limits of the peninsula, we have an area comprising over four-fifths of the entire peninsula. Yet so much of what is observed within the larger territory being but a repetition of what occurs to the north, the subject of the gravels, in the way it is treated, is about equally divided. Generally speaking, we may say that from the northern limit above indicated to about the latitude of Dover, the region is covered by both members of the *Delaware gravels*, with their usual thickness well maintained throughout. They are very morainic in their characters, rising into elevations sometimes reaching fifty feet, with corresponding depressions. Over the surface everywhere are scattered an abundance of bowlders, large and small, the upper brick clay becoming a stratum of coarse gravel or bowlder clay. As we pass to the south of Dover, however, appearances change, the country becomes gradually less undulating, and the gravels less coarse, the change being indeed so gradual as to be imperceptible. At a distance as far south as Murderkill Creek, the lower red sand, instead of being a coarse gravelly stratum, is a uniformly coarse sand of the same color, and comparatively free from gravel. It is always overlaid with a foot or two of white sandy loam, free from coarse gravel, but containing smaller rounded pebbles of glassy or jaspery quartz and quartzite, together with subangular fragments of chert and hornstone, the latter being often fossiliferous. Covering the surface of the sandy loam, quartzitic bowlders are found, but in less abundance than over the northern area. As we continue southward, even *to the utmost limits of the peninsula*, the country becomes nearly flat, the red and brown sands change to a lighter color, until quite white, in which case the two members of the gravels merge into each other. At numerous localities within this region of white sands, however, the latter become distinctly red and brown with so large an admixture of gravel as to become identical with the red gravels of New Castle County, in which case there is always an overlying layer of white loam bearing upon its surface the characteristic bowlders. Often, again, we see one thick stratum of white sand, in which are streaks of red in varying quantity, while oftener still, the white sand assumes a slightly reddish tinge.

Origin of the Southern Sand and Gravel.—From the above facts, there can be no doubt but that the white sands which cover over one-half of the area of the peninsula are contemporaneous with the *Delaware gravels;* but the two differ entirely as regards origin. While the *Delaware gravels* were a fluviatile deposit spread out over the upper portion of the estuary floor, the white sands were of marine origin, the deposition taking place at the broad mouth of the estuary and at a considerable distance out in the open sea. The probable truth of this statement is further shown by the finding of modern marine shells in the lower part of the white loam, near its junction with the tertiary blue clay, of which mention will be made shortly.

To account for the intimate mingling of the red gravel with the white sands, we suppose that as the red gravel from the north met the morainic sands of the south, the two became mixed, thus producing a gradual merging of the one into the other. Further, outcoming tides would carry loads of the fluviatile red gravel far to the south, where it would become interstratified with the white sand.

This lower deposit of white sand and gravel we shall designate the *Estuary sands.*

Professor J. C. Booth, in his Report upon Delaware (1841), attributed the white estuary sand to the destruction of ancient dunes which have gradually been blown far inland. The basis of that theory was the finding of dunes as far to the west as the town of Seaford, and the observation there and elsewhere of a similarity between these sands and those which formed the universal covering. This hypothesis is, I think, a mistaken one. In the first place, dune sand is entirely free from fine and coarse pebbles. A careful study by the writer of the dunes of the coast revealed no pebbles even as large as one-half inch in diameter, while the estuary sands revealed everywhere an abundant mixture of pebbles of this size with a smaller quantity of quartzitic pebbles from one-half to three inches in diameter; and in still rarer cases, as at Milford and Seaford, cobblestones and small bowlders have been dug out of the white and red sand deposit. Bowlders are, furthermore, everywhere found covering the surface of the estuary sands to even the southernmost limit, some of the largest being found at Snow Hill, Md. They therefore must have been dropped by ice-rafts borne upon the waters of the Post-Glacial estuary, in which were deposited the white sand and gravel upon which they lie. In the neighborhood of Seaford, one may readily perceive the relation of the dunes to the estuary sand.

While the former are extremely loose and fine, free from even the smallest pebbles, the latter is a rather coarse loam, containing enough clay to hold it together and sometimes to pack hard, mixed with a due proportion of fine gravel. Instead of the meridional sand hills having been produced by the blowing in of that material from the sea, it seems more probable that they were made by the shifting and accumulation of the finer particles of the estuary deposit. As the surface of this sand stratum becomes dry, there is seen to form a thin film or efflorescence of fine white sand which the writer has observed is readily taken up by the wind and shifted in various directions. Any slight obstacle, such as a fallen tree, would form a barrier or nucleus of accumulation, from which might grow a dune of considerable size. This must appear to any careful observer the origin of the interior dunes of the Delaware peninsula.

The age of the Estuary sands.—The estuary sands forming a stratigraphical continuation of the *Delaware gravels* are contemporaneous with them, while this latter material, finding its source in the fluviatile gravels of the Delaware river valley, is undoubtedly Post-glacial, especially as the vast amount of bowlder drift associated with it can have none other than an iceberg origin. But, besides this proof of age, we have that which is still more certain.

In the lower part of the estuary sands near its junction with the clay have been found nests of modern shells, of which the most common species is the modern oyster (*O. Virginica*). These have been found in some four or five localities of Sussex County. Near Dagsborough a nest of broken fragments of the oyster shell was found, with which were also well preserved specimens of the *Tritia trivittata* and *Urosalpinx cinerea*, well-known littoral gastropods still living upon the Atlantic coast. In Baltimore Hundred the oyster shell was found associated with *Venus mercenaria* and *Fulgur canaliculatus.* For an examination of these modern shells from the *Estuary sands*, I am indebted to Professor Angelo Heilprin.

Local details.—In the vicinity of Smyrna and from the westward to the State boundary, the Delaware Gravels become unusually coarse, attaining a thickness of from 30 to 35 feet. The bowlders, cobble stones and pebbles are of both glassy and quartzitic varieties, the latter running into a ferruginous conglomerate and sandstone. Two miles west of Clayton one bowlder of conglomerate was found to measure 3′×2′×1′, with which were subangular fragments of coarse granite and cellular quartz similar to buhrstone. At Dover the same coarse gravels continue, and rise as moraines of considerable size. A fresh cutting within the limits of the town gave the following section:—

1. A black sandy loam	9″—6″
2. A sandy brick clay	1·5′
3. A red sand compactly bedded	25′
4. A blue clay—Tertiary.	

Along Jones Creek the gravels rise as high bluffs, and can be well studied. The pebbles are usually quartzitic, very commonly finely laminated, but with a considerable admixture of the glassy varieties, also yellow and black jasper. The less common pebble and bowlder representatives are—red, yellow and brown friable sandstone, fragments of pudding stone and ferruginous grit, gneiss, granite, trap, and white compact crystalline limestone.

Very commonly over the surface are found rounded and subangular pebbles and slabs of a greenish or brownish argillaceous sandstone, very similar to the Chemung. They frequently contain excellent specimens of the *Spirifer mucronatus*, and one piece exhibited to the writer a species of *Leptæna*. Another slab showed markings which appeared to be indisputable glacial scratches. At the Dover railway station, in a fresh cutting, the red sand showed beautiful examples of both oblique laminations and flow-and-plunge structure. Well rounded bowlders of both vitreous quartz and quartzite are common, many of them weighing not less than 500 pounds. Between Harrington and Milford, we are well within the region of white sands, but adjacent to Milford the red sand is abundantly interstratified with the white with which are also occasional seams of coarse pebbles, thus giving the deposit a highly gravely aspect. At Bridgeville, the interstratified seams of red sand are equally well developed, but the usual surface deposit is a coarse gray sand which here attains a thickness of over twenty feet. At Seaford, a little farther south, the gray sands reach an equal thickness. At the railway station of the above place we got the following section:—

1.	Red and white sand	5′
2.	Quartzitic pebbles	2″ ±
3.	Red sand	4′
4.	Irregular layer of pebbles—level of run	3″

Passing to the east of both Seaford and Bridgeville, and to the neighborhood of Georgetown, the white sand maintains the same character, but shows less thickness, varying from 3 to 15 feet with an average of about 8. Between Georgetown and Lewes, the sands are commonly of a slightly reddish tinge, running into white, and again into sand of a distinctly red or brown color. Three miles from Georgetown the road to Lewes cuts through a hill of coarse gravel, which, trending for several miles in a N.W. and S.E. direction, attains a height of fifty feet. Another similar hill of coarse gravel is found to the east of Ellendale. These are, in both cases, but swellings in the white sand and only differ from the latter in the large admixture of coarse pebbles, varying in size from one to three inches in diameter. In passing to the south of Georgetown, nothing new can be learned by citing localities. The surface stratum is a uniformly white or reddish-white sand having a thickness of from 6 to 10 feet, with generally a small proportion of fine gravel. At nearly all points, however, bowlders are found. At Snow Hill, Md., these bowlders are of frequent occurrence and have been collected into waste piles. They vary in weight from a few pounds to more than a man could lift. Among the rock species we may mention yellow jaspery quartz, brown conglomerate, a light granitic gneiss, a dark hornblendic gneiss, a coarse grained highly feldspathic granite, a dark blue slate rock and quartzite. A close study of the numerous bowlders at this point showed some indisputable evidences of glacial scratches, the most pronounced instance being a large well rounded bowlder of dark green diorite, the smooth surface of which was covered with very fine scratches, clearly of glacial origin.

Neck Lands.—This name is given to that slip of low marshy land which borders the bay shore. Its basis is an unpenetrated stratum of blue or black clay in which have sometimes been found by those living in the vicinity nests of modern oyster and clam shells. The deposit is identical with the bog clay of the river bank; so that we may say that from Wilmington to the southern line of the State into Maryland, the river and bay are edged with a belt of modern bog clay, varying in width from one to three miles.

Within the southern area, the marsh land is bordered for its entire length by the lowland terrace, which presents the same winding course, and rises to a height of from 10 to 15 feet. In some localities, at points nearer the terrace, this bog land is above the reach of high tide, a fact which would indicate a present elevation of the coast. The fishermen assert emphatically that the Delaware shore is rising; and at Lewes, these assertions are authenticated. Boat-houses which were once at a convenient distance from the water have frequently been moved nearer, of necessity. An old yacht, said to have been wrecked twenty-five years ago, is now lying not less than 50 feet inland and 3 or 4 feet above mean tide.

While no attempt is here made to measure the rate of elevation, there is no doubt but that the fact of such an elevation can be established. The New Jersey coast and the shore of the southern Atlantic States show evidence of a slow subsidence; but these coast regions have not been covered by the sea since the later Tertiary, while the Delaware peninsula, totally submerged only as far back as the Post-Glacial, has not finished the slow operation of emergence from the sea.

ART. XI.—*Report of the Superintendent of the United States Coast and Geodetic Survey showing the progress of the work during the fiscal year ending with June*, 1883.*

ON December 1, 1833, Mr. F. R. Hassler, Superintendent of the Coast Survey, presented to the Secretary of the Treasury a letter reporting the progress made in the work of the survey of the coast.

Excepting a report (of 3 octavo pages) to the Secretary of the Treasury in November, 1817, also by Mr. Hassler, this was the *first* Coast Survey report, and for about ten years it was followed by similar reports consisting of a few octavo pages. In 1844, under the superintendence of Prof. A. D. Bache, these annual reports to Congress, which appeared as executive documents, began to grow, and in 1851 had attained to a size of 559 octavo pages. Beginning with 1852, however, the form was changed; the octavo form was abandoned, and in its stead came the quarto, so much better adapted to the presentation of maps and illustrations.

The report for 1852 may therefore be regarded as the beginning of a series of which the volume before us is the thirty-second.

The publication of these annual reports of progress has continued, sometimes with delay but without interruption, and the prompt issue of the present volume indicates that the delay in the publication of the later volumes is practically overcome.

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* xxvi and 448 pp, 4to, with 50 maps, sketches and illustrations. Washington, 1884. Government Printing Office.

During the fiscal year 1882–3 the annual reports for 1878, 1879 and 1880 were printed and distributed, and "but for a contractor's failure to produce the sketches and illustrations in time" the 1881 report would have been found in the same category.

But the 1881 report was actually issued more than a year ago, shortly followed by that for 1882, and now the 1883 report has promptly followed.

That this volume should be a worthy successor in this long series we have a right to expect, and we are not disappointed. From the nature of the subjects treated in the scientific parts of these volumes it is but natural that some volumes would prove of more popular interest, or of interest to a larger class of readers than others. The appendices in the present volume, Nos. 12 and 14 *on refraction in connection with hypsometric measurements* and on *standard topographical drawings*, are likely to render this a volume for which there will be more than the usual demand.

The report before us departs but very little in its form, or general make-up, or class of topics treated, from its predecessors.

The general form, originally adopted in this series, has required and indeed has received very little modification during its 33 years of existence. Broadly stated, these reports present two classes of facts and for two classes of readers. The first may be called the *official* and the second the *scientific* report.

The *official* report presents brief statements of results obtained, then the same in greater detail; also, statements of when, where and by whom the work of the survey has been carried on, and an estimate for the use of Congress of the money necessary to carry on proposed work. This is followed by reports from the various divisions into which the office work is divided, giving statistics of the work done during the year. This official part may then be regarded as an exhibit of the machinery by which results are obtained, with figures showing the capacity of the machine.

The *scientific* part of the report is embodied in appendices prepared by specialists in the survey, who digest the raw material, deduce general laws or principles and point the way to improvements in methods and results. The volumes do not in form exactly conform to this. From a scientific point of view such an arrangement would doubtless be preferable, but whether expedient or not must be decided by the survey itself. Even as it is, the "make-up" of the volume is so well done that no one consulting it need lose time in finding what he seeks. The table of contents, list of appendices and their contents, list of sketches and illustrations, and the alphabetical index of 18 pages, furnish the needful guides for rapid consultation. That this is Senate Ex. Doc. No. 29, 48th Congress, 1st Session, the bibliographer will not learn from the volume itself. This absence we pardon the more readily on account of the improved appearance of the title page. Still this useful piece of information might have been somewhere retained.

The report proper consists of 74 pages in two parts; the *first* of 11 pages, giving results in the most general terms and closing with *Estimates*, and the *second* of 63 pages giving in detail accounts of the work done in the 17 sections into which the territory of the United States (Alaska included) has been divided.

Appendices 1 to 5 inclusive, 46 pages, contain statistical information and reports from heads of various divisions, etc. While in general form these appendices are like their predecessors, we note some changes. There is a report to the Superintendent of the Assistant in charge of Office, to which report are appended reports from the Computing, Drawing, Engraving, Instrumental, Tidal and Miscellaneous divisions, and from the custodian of the Archives.

Great activity in hydrographic work is shown during this year, as appears from the report of the Hydrographic Inspector; 95 naval officers, and 21 of the 25 vessels being in service.

Appendices 6 to 19, pp. 121–488, constitute the scientific part of this report and cover a variety of subjects, such as Astronomy, Bibliography, Geodesy, Gravity, Magnetism, Tides, etc.

The bibliography, which is by Assistant Edward Goodfellow, and covers 15 pages, is entitled a "*Descriptive catalogue of publications relating to the Coast and Geodetic Survey and to standard measures.*"

This catalogue of the publications of the survey is classified under the several heads of Annual Reports, General Index of Scientific Papers, Lists of Tide Tables, of Coast Pilots, of Chart Catalogues, Notices to Mariners and Special publications. Although only a descriptive and not an analytical catalogue, the references in its tabular lists to the dates, forms and modes of publication are sufficiently explicit to enable any librarian to complete the classified list of Coast Survey publications which may form part of his catalogue.

Appendix No. 7 is an elaborate table of 100 pages, showing the depth of water which can be carried into various harbors of the United States and adjoining coasts. This is a practical rather than a scientific matter, and its value for the use of commerce and navigation is readily perceived.

In Appendix No. 8, Assistant Henry Mitchell presents in a very brief form, the condensed results of an elaborate and careful study of what he terms the *Estuary of the Delaware*, being that part of the Delaware river between Philadelphia and a point 53 miles below. In this stretch of water, 734 lines of soundings have been run across the river, from which data the area of section and average depth have been calculated and tabulated. These resúlts are presented in tables and in diagrams and strongly reinforce a conclusion based upon preliminary data and published in the C. & G. S. Report of 1879; this conclusion is that, in the language of the Superintendent, "*In the Estuary of the Delaware from League Island to the submerged delta, the mean depth is constant; the widths and sections vary with the square of the distance, and the retard of the tide can be exactly stated in terms of the mean depth and width.*"

Mathematically, then, these relations are expressed by equations of parabolas in which the constants have been empirically determined.

Let x be the distance of any section of the river from the Fort Mifflin section, down stream, measured along mid stream and in nautical miles; then we have

Mean depth in feet $= 18{\cdot}64$
Mean width of stream in feet $= 10{\cdot}1x^2 + 5100$; and
Mean area of section in sq. ft. $= 188x^2 + 95000$.

The curves resulting from observation agree well with the curves resulting from these equations, particularly the latter, in which the coefficient 188 results from multiplying the preceding coefficient 10·1 by the average depth 18·64 feet. This depth, 18·64, is the mean of all the soundings in the river for 46 miles below Fort Mifflin.

The expression for high water is stated to be

5·11 *distance* − 0·0018 *width* + 92 *minutes* where "*each term has its distinct physical meaning,*" but what that meaning is we are not told.

A sketch of the estuary accompanies this appendix.

Professor Wm. Ferrel, whose mathematical researches in practical directions have been so valuable, contributes two papers upon a topic peculiarly his own, viz: the tides. The first is a brief account of the results of the harmonic analysis of the tides at Sandy Hook, 1876–1881. It has special reference to determining the constants necessary to be used for this place in the tide-predicting machine.

Incidentally the mass of the moon is deduced from these 6 years' observations, and found to be between $\frac{1}{74}$ and $\frac{1}{77}$, the corresponding determination from the Penobscot Bay tides being $\frac{1}{85}$ and from the Boston tides $\frac{1}{75.1}$.

The *second* paper, however,—Description of a maxima and minima tide-predicting machine—is a much more important paper. Besides it is self-contained and, therefore, does not require the examination of other papers to be understood.

After a brief introductory note alluding to the tide-predicting machine of Sir Wm. Thomson, first constructed about 1875 and the subsequent enlarged and improved one constructed under the direction of Mr. E. Roberts in 1879, Prof. Ferrel proceeds to describe and explain, both theoretically and practically the workings of the machine devised by him, and constructed at the Coast and Geodetic Survey Office under his direction, for predicting the *times and heights of high and low water* for any given station.

In Thomson's machine and its successor—now in successful operation for predicting tides on the coast of India the machine traces the tidal curve on a long strip of paper. From this strip of paper the times and heights are to be read off and tabulated in form for printing and publication. This machine, therefore, makes known the height of the tide for every instant.

In the machine now first constructed and described by Prof. Ferrel we obtain *not* a curve giving the height of the tide at all times; but for the particular times we desire, viz: at high water and at low water we obtain the times and heights. The machine, therefore, which gives these results is for distinction called a "*Maxima and minima tide-predicting machine.*"

It is of interest to note that the theory upon which the machine solves the tidal problem is more accurate than the usual mode of computing. In the words of the author:

"The formulæ used in the machine are those best adapted to obtain the results accurately by computation. This, however, involves so great an amount of labor that it has been necessary heretofore to use more simple formulæ, requiring much less labor in computation, but which give often only very rough approximations to the true results. These can now be pretty accurately obtained with scarcely any labor."

Against this greater theoretical accuracy must be set off the inaccuracies due to mechanical construction; but when this has been done the machine still shows results quite equal to the results obtained by direct computation even when tested by tides so different as those at Boston, San Diego and Tahiti.

In capacity for doing work the author estimates the machine to be equivalent "to 30 or 40 computers, if these were to take account of everything which the machine does."

According to this estimate we may say that if *one* computer could by the usual mode of computation make the tide-tables for the Atlantic sea-coast of the United States in *one* year *without* the machine, then *with* the machine he would in one year predict the Atlantic tides for the next 30 or 40 years.

When it is borne in mind that the constants for setting the machine are to be computed beforehand for each station, each year of observations by itself according to the author's plan, and that to derive the constants from one year's observations will take an experienced computer several months, we see that the efficiency of the machine has been counted from where this long preliminary computation left off. Practically, therefore, its present efficiency is very materially less than 30 computers.

When once the tidal observations at a station have been completely put through the laborious harmonic analysis and the machine constants calculated, then it may be that the machine can predict for that station in one day as much as it would take a computer 30 or 40 days to do.

A comprehensive understanding of this valuable paper is only to be obtained from a careful study of the paper itself and of the five sketches with which it is illustrated.

We note that Plate III, the *front* view of the machine, is in the list of sketches called *back* view, while Plate IV the *back*, is called *front* view. This would have been obviated by printing legends on the plates themselves.

In appendix 11, Mr. C. A. Schott discusses the observations for the length of the Yolo base line. This base line, it will be remembered, is a very important primary one in the Sacramento Valley, California, and is the measured basis for the western end of the trans-continental system of triangulation. The apparatus, of an entirely new design, and the method of observing were fully described in the report of 1882. We now have the result; this result is that we have a measured base line about 11 statute miles in length, and the uncertainty in this measure is only about $\frac{3}{8}$ of an inch, or in meters the Yolo base line is

$$17\,486{\cdot}^{\mathrm{m}}5119 \pm 9{\cdot}57^{\mathrm{mm}}.$$

In length the whole line was measured twice, and a part of it three times, and this by a corps of the most qualified and experienced men in the survey. No known precaution for obtaining a measure of high precision was omitted, and the result obtained now shows a measure far surpassing in accuracy any previous measure by the survey, and, with a single exception, the most accurate base measure yet secured anywhere. Not the least satisfactory part of the whole matter is the clear summing up and presentation of results in print. The appendices in these reports from year to year show, in spite of good editing, marked differences in this respect.

In the 12th appendix, Asst. Schott discusses the third series of observations made, by Asst. Davidson and party in California, for determining the coefficient of refraction.

The difference of level of two stations, Mt. Diablo and Martinez East, was determined by spirit leveling to be 1116·09 meters (3661·7 feet). This difference of level was also further determined from hourly readings of the barometer for about 40 days, and also from hourly observations of reciprocal zenith distances during the same time, whenever the weather permitted. The results by the three methods are compared and some general principles deduced.

In the 13th appendix, also prepared by Mr. Schott, we have the first general account, with results from magnetic observations, of the U. S. International Polar Station at Ooglaamie near Point Barrow, Alaska. Mr. Schott makes very clear at the outset, the nature and extent of the coöperation which the survey was able to give. This coöperation related solely to terrestrial magnetism, and this appendix is entirely devoted to a discussion of the results obtained. Owing to the want of trained observers and the necessary instruments, whose production requires time, the coöperation the first year was "incidental" rather than complete. The second year additional instruments and an additional observer rendered the coöperation much more complete and satisfactory.

Regular magnetic observations began December 1, 1881, and continued hourly, with two short interruptions, till August 27, 1883, giving a series of about 21 months. The observations during the year 1881–2 consisted of hourly observations of the declinometer and dip circle (with needle weighted), and the term day observations. During the year 1882–3, differential magnetometers were in place and gave hourly readings of declination, horizontal force and vertical force. The absolute measures of the elements were continued through this second year.

The estimate of Mr. Schott, who has gone over these records with laborious fidelity is that the "*records and results herewith presented are the outcome of faithful labor, and are believed to be an acceptable contribution to our knowledge of magnetism in high latitudes, and it is thought that in the second year, at least, these records will prove to be a valuable part of the material accumulated by the several expeditions.*" We hasten to add to this that Mr. Schott's experience, skill and diligence in the discussion of magnetic observations are shown by the long series of papers on this subject from his pen during the past thirty years, and if, therefore, he has succeeded in extracting a "contribution to our knowledge" from a series of observations that reveal serious self-contradictions, important omissions and defects which nothing but patient ingenuity and skill can harmonize even roughly, he deserves our hearty thanks. No one experienced in the study of terrestrial magnetism is ignorant of the fact that his own earlier observations were poor, and improved with experience. We may, therefore, judge the character of these observations when we know that not a single member of the party at Point Barrow had ever made the simplest determination of a magnetic element when assigned to this work. That the observers obeyed orders and did the best they could is not to be doubted for a moment. Nor is it any less certain that they were all inexperienced in magnetic work, and that therefore their observations are bad, many of them very bad. The extraordinary torsion correction, for the proper determination of which no proper data were furnished and which amount to 5½° ! in some cases, will illustrate the difficulties confronting the author beginning his reductions and computations.

The finally adopted values of the magnetic elements at the station from all the observations available, are,

Declination	35° 37′·2 E.	(Epoch Mar. 1, 1883).
Dip	81° 23′·4	(Epocn October, 1882).
Hor. force (Br. units)	1·939	(Epoch October, 1882).

The results for absolute declination as derived from the computations by the observers themselves varied from 35¼° to 41½°; but for the greater part the mean declination obtained was about 41¼° E. The value which from a comparison of all the conflicting data Mr. Schott has been obliged to adopt is, as above given, some 5½ degrees less than this.

The report of Asst. Edwin Hergesheimer on standard topographical drawings consists of two pages of letterpress and 16 topographical drawings which are designed and executed as models for the use and guidance of those engaged in topography. The author himself says they are designed as "guides for inking the original plane table sheets of the Coast and Geodetic Survey," in other words as model sheets. As evidence that they satisfy this requirement it may be said that already two large technical schools in this country have ordered a large number of copies of this report for use as a text-book in topography. Excellent as are these drawings, even after their transfer to the stone, the impressions from the original copper plate are yet more satisfactory, while the original drawings of Mr. Hergesheimer represent the highest attainments thus far achieved in topographical representation.

Appendices 15 and 16 contain brief reports on the Transit of Mercury in 1881 and of Venus in 1882, while appendix 17 is a brief report by E. D. Preston, consisting of a statement of the work done by him in connection with the observations of the solar eclipse of May, 1883.

Appendix 18 is a new, revised and enlarged edition of Prof. Davidson's catalogue of time and circumpolar stars published in 1874. The number of stars in the old catalogue was 983, while in this one there are 1278, and the epoch is 1885·0.

The final appendix, No. 19, is on gravity determinations at Alleghany, Ebensburgh and York, Pennsylvania, in 1879 and 1880, by Asst. C. S. Peirce. From notes in the midst of the paper we learn that this is only a part of a separately printed paper on the same subject in which the details are given. For an understanding of the method of obtaining results reference must be had to previous publications by the same author.

The resulting length of the seconds-pendulum, expressed in meters, at the three stations of which the paper treats are as follows:

Alleghany	0^{m}·993 0308
Ebensburgh	0 ·993 0244
York	0 ·993 053

the latter determination being less strong than the two preceding.

We have looked with interest to these results to learn whether a station, as Ebensburgh on the crest of a mountain chain and more than 2000 feet above the sea-level, would reveal an excess or deficiency of gravity, but upon this matter the author makes no statement.

The sketches at the close of the volume revealing the progress of the survey during the year are prepared from plates which have seen service many years, and this fact appears in a variety of ways, particularly in the titles of which the later are much improved in appearance over the earlier ones.

A general comparison of this report with those preceding it by a few years indicates an improvement in arrangement, and a closer adaptation to the present conditions of the work. Special prominence is given to discoveries and developments having an immediate bearing on the interests of commerce and navigation. In the scientific value and practical bearing of the papers published in the Appendices, the Report compares well with its predecessors.

ART. XII.—*On Combinations of Silver Chloride, Bromide and Iodide with Coloring Matters;* by M. CAREY LEA, Philadelphia.

WHILE studying these silver salts in May last, I found that they had the remarkable property of entering into chemical combination with many coloring matters very much in the same way that alumina does, though not to the same extent, forming what may be called lakes. It is only necessary to bring freshly precipitated and still moist silver salt into contact with the coloring matter, or to make the precipitation in the presence of the coloring matter if the latter is not precipitated by silver nitrate, when the combination takes place and the coloring matter cannot be washed out by any amount of washing. A prolonged absence following immediately after has prevented the continuation of the investigation. It is still incomplete and the leading facts only are mentioned here to take date.

Not all coloring matters are capable of uniting with the silver salts, but the number of those that do so unite is considerable. What is curious and tends to show that the combination is intimate is that the color assumed by the silver salt is not always that of the dye, but may differ from it considerably. Also the three silver salts may be differently colored by one and the same coloring matter.

More frequently, however, coloring matters impart their own shade or something approaching to it; thus, silver bromide precipitated in presence of excess of silver nitrate takes from aniline purple a strong purple color; from cardinal red a bright flesh or salmon color; from napthaline yellow a light yellow color; from eosin a brilliant pinkish or salmon, and so on.

Different specimens of the same color gave sometimes quite different results; thus silver bromide precipitated in presence of silver nitrate was dyed by one specimen of methyl green to a bluish green. Another specimen of the same color obtained from a different source colored the same silver salt a deep purplish shade. Silver iodide showed the same difference.

Sixteen years ago, I proposed to color or stain the photographic film in order to modify its behavior towards light; principally to prevent blurring or irradiation.*

Of many coloring matters then tried, the best proved to be litmus colored red by acetic acid. This was very effectual for the purpose and was long used by others as well as myself. So far as I have been able to ascertain, it was the first suggestion made of this mode of acting on the sensitive plate. Since then staining the film has been found to have other applications and many others have experimented in this direction, in most cases with a view to alter its sensitiveness relatively to the different colors of the spectrum. Major Waterhouse was, I believe, the first to recognize this effect.

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* British Journal of Photography, 1868, 210, 506; 1870, 145, etc.

Dr. John W. Draper appears to have first advanced the view that substances sensitive to light are affected by the rays which they absorb. There is much to support this theory, although it cannot be considered as definitely established.

Some years since Dr. H. W. Vogel expressed the opinion that when sensitive films were washed over with solutions of coloring matters, the films gained sensitiveness to those rays of the spectrum which the coloring matters absorb, with this condition, that the coloring matter in question must be capable of combining with Cl, Br, or I, as the case might be. My own results were different. I found that the action of the rays was profoundly modified by coloring the film, but the result did not seem to conform to any law, and as often contradicted Vogel's view as agreed with it.

Vogel's theory necessitates the assumption that the color imparted to the silver salt is identical with that of the dye used, and as has been shown above, that by no means follows. He supposed that the capacity of any given color to influence the silver salt depended upon its tendency to combine with Cl, Br, and I, whereas, as we have above seen, its action most probably depends upon its ability or inability to combine with the silver haloid.

But the principal source of error has arisen from the fact that when the film is stained the effect is necessarily a confused one. Besides any influence that may be exerted on the particles of silver haloid, these particles are virtually behind a color screen, which must materially modify the nature of the light that reaches them, and the final effect must necessarily be a combination from two distinct causes. Moreover, the color in the film tends to arrest precisely those rays to which it is proposed to render the silver salt more sensitive; a consideration of the utmost importance, for the one action tends to counteract the other, and thus leads to inextricable confusion. From a system of experiments so faulty no just conclusions could be drawn.

Whether with these sources of error eliminated Draper's view, that a sensitive substance is influenced by those rays which it absorbs, can be applied to these new combinations which I have here described, is a matter on which I am not prepared to express an opinion, having been, much to my regret, unable as yet to examine the question. It seems *à priori* probable, but in that case it is important to observe that *the effect will depend firstly, upon the capacity of the dye to combine with the silver haloid; and secondly, not on the proper color of the dye isolated, but on the color that the silver haloid acquires under its action*, which as we have already seen may be something quite different from the color of the original dye.

I have observed that the silver salts are greatly changed by conversion into lakes, even when the color imparted is but faint. They become in some cases much more finely divided and remain long in suspension. In one case at least, a great increase of sensitiveness to light for development was observed. Later I shall hope to give more definite details on these points.

In the above facts will doubtless be found an explanation of many of the anomalies in the behavior of colored films which have caused such wide differences of opinion. And the new modes of operating deducible from the reactions here described will, I think, be found of extended utility. Silver salts can be dyed first and emulsified afterwards, and the ability to color the sensitive salt to any shade with certainty and without introducing a counteracting influence into the film gives a new power in photochemistry.

Art. XIII.—*On the present state of our knowledge of Refraction Equivalents;* by Dr. J. H. Gladstone, F.R.S.

It is well known that every substance has its refractive index, but this varies with change of temperature or pressure, and by the passage from the fluid to the gaseous or solid condition.

The specific refraction of a substance, that is the refractive index minus unity divided by the density, does not vary under the above circumstances, or varies but little.

The specific refraction multiplied by the atomic weight is termed the Refraction Equivalent of a body; and it is a law deduced from a very large number of observations by several experimenters that the refraction equivalent of a compound body is the sum of the refraction equivalents of its constituents.

If this law held true absolutely (like the analogous law in regard to atomic weights), we could draw up a table of the refraction equivalent of each element, and show some curious and suggestive relations between them; we could calculate beforehand the refraction of every compound body if we only knew its specific gravity; and there the value of the investigation would probably cease.

But the law does not hold good in every instance. The refraction equivalents of the elements vary with a change of valency, or mode of combination, and thus the study of them is capable of affording valuable insight into the chemical structure of compound bodies.

This fact has been recognized for several years, but the researches of Brühl, published about three years ago, drew far more attention to it, especially as he showed that wherever a carbon atom is in that condition which chemists often express as "double linked" its refraction equivalent is no longer 5·0, but 6·1, and that oxygen in organic compounds has two equivalents according to its manner of linking. During the past twelve-month papers have appeared on this subject, not only in England, but in other countries, especially by Nasini of Rome, Kanonnikow of the Kasan University, G. Quincke, and Bleekrode of the Hague.

These recent papers have not only added largely to our data, but they have had an important bearing on several branches of the subject; for instance:—

1st. They have thrown fresh light on the physical questions at the basis of the enquiry. Thus Bleekrode, in a communication made to the Royal Society of London, has examined the specific refraction of eleven liquified gases, and has shown that it is the same for the liquid and the gaseous conditions, at least within limits that may probably be attributed to the errors incidental to so difficult an enquiry. Kanonnikow has given additional proofs that the specific refraction of a salt or other solid body is not altered by solution. It has been shown more fully than before that the specific refraction is a constant unaffected by change of volume due to pressure. There is also an accumulated mass of evidence that this same property is not changed by ordinary chemical combination.

2d. These investigations have rendered the determinations of the refraction equivalents more exact. Thus Kanonnikow has examined salts of the metals contained in the two first columns of Mendelejeff's table, with results not differing widely from those previously obtained by the author; and Nasini has determined two values for sulphur. From these and other recent researches the author has been induced to revise the table printed by him in the Philosophical Transactions of 1869 with the result given below.*

3d. Deductions have been drawn as to the chemical constitution of various organic bodies. Some of these are at present the subject of discussions by Flavitzky and others in various continental journals. As the last instance of such deduction the author had examined the optical properties of pentine and isoprene, C_5H_8, just described by Tilden, and had come to the conclusion that they differ constitutionally from the terpenes or citrenes, $C_{10}H_{16}$, and have no less than four of the carbons double linked: they must therefore be expressed by a chain formula like pentane, C_5H_{12}, and amylene C_5H_{10}.

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* Since the paper was read at Montreal some of the atomic weights have been advised in accordance with the recent determinations of Professor Clarke and others.

Element.	Atomic weight.	Refraction. Equivalent.
Aluminium,	27	7·7
Antimony,	120·2	24·1
Arsenic,	75	15·4
Barium,	137	15·8
Beryllium,	9·1	5·0
Bismuth.	208	38·2
Boron in borates,	11	about 4
Bromine,	80	15·3
Cadmium,	112	13·1
Cæsium,	133	19·2
Calcium,	40	10·0
Carbon,	12	5·0
Carbon, double linked,	12	6·1
Cerium,	141	20·0
Chlorine,	35·5	9·9
Chromium,	52·1	15·3
Chromium in chromates,	52·1	about 22
Cobalt,	57	10·4
Copper,	63·3	11·5
Didymium,	145	23·1
Fluorine,	19	1·6?
Gold.	196·6	23·1
Hydrogen,	1	1·3
Iodine.	126·8	24·5
Iron. bivalent,	56	11·6
Iron, trivalent,	56	19·4
Lanthanum,	139	23·0
Lead,	207	24·3
Lithium,	7	3·5
Magnesium,	24	6·7
Manganese,	54	11·5
Manganese in permanganates,	54	about 25
Mercury,	200	19·4?
Nickel,	58	9·9
Nitrogen,	14	4·1
Nitrogen in bases,oxides,&c.	14	5·1
Oxygen, single bonds,	16	2·8
Oxygen, double bonds,	16	3·4
Palladium,	106	21·6?
Phosphorus,	31	18·3
Platinum,	195	24·7
Potassium,	39·1	7·85
Rhodium,	104·3	23·6?
Rubidium,	85·5	12·1
Selenium,	79	30·5
Silicium,	28·2	7·4
Silicium in silicic acid,	28·2	about 6
Silver.	108	13·2
Sodium,	23	4·4
Strontium,	87·5	13·0
Sulphur,	32	16·0
Sulphur. single bonds,	32	14·1
Thallium,	204·2	20·4
Tin, bivalent,	118	27·0?
Tin, quadrivalent,	118	18·6?
Titanium,	48	24·6
Uranium,	239	19·5
Vanadium,	51·3	24·8?
Zinc,	65	9·8
Zirconium,	89·6	21·2

ART. XIV.—*Decay of Quartzyte: Pseudo-breccia*; by JAMES D. DANA.

IN the paper on the "Decay of Quartzyte" published in the last volume of this Journal, I briefly mentioned the occurrence of druses of quartz crystals coating the surfaces of cavities in the iron-colored bands and covering also the limonite in the larger cavities. I said nothing on the origin of these evidently recent quartz deposits. I add here the only fact as yet obtained that seems to bear on the subject. The mass of quartzyte shows by the occurrence in it of a few large ragged cavities, and also of many minute holes near and also away from the colored bands, visible under a common lens, but better in thin sections under a compound microscope, that the rock probably contained grains and larger pieces of feldspar. If so, alkaline silicated solutions (derived from the action of carbonated waters on the feldspar) may have been the source of the crystals. So much of the quartzyte of Berkshire is of this feldspathic character that the supposition is reasonable; but more facts are needed to sustain it. The feldspar (orthoclase) in the quartzyte of Cheshire and Washington (referred to in the former article) occurs both in fine grains and large.

In the making of the pseudo-breccia the iron-colored bands are largely, as I stated, only stained quartzyte, the staining due to the spreading of the oxide either side of a crack. This is well seen in thin sections. The crack is generally a result of the wedging action consequent on the deposition of the iron oxide within an incipient crack or opening. This wedging action, in most of the pseudo-breccia specimens I have collected, has been small, the pieces lying very nearly in place, notwithstanding the appearance of large displacement occasioned by the spread of the oxide. But in one of the specimens it is relatively large, some of the intervals between the pieces being a sixteenth of an inch wide. Where the width is greater than this, pieces of the quarzyte occur within the band of oxide that are results of the septation process. In the specimen here referred to the oxide is oxide of manganese. In the wider openings it makes mammillary crusts over the opposite surface of the fissures, but extends across the fissure in some parts. There are no quartz incrustations. The opening of cracks by a wedging action from the slow depositing of a crystallizing mineral substance is finely illustrated in the well-known split and enlarged heads and stems of crinoids, from the Sub-carboniferous limestones of Indiana, Illinois, etc., in which the introduced mineral is quartz. The specimen here referred to (three-fourths of a pound in weight) is one-sixth manganese oxide, and consequently the oxide must have come from an external source. It was obtained at one of the Limonite ore-beds near the eastern foot of Mt. Washington, where manganese oxide was the chief product; and it was originally a mass of quartzyte in the drift; there is no quartzyte in place in the vicinity. It contains some scales of a silvery muscovite.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Viscosity of gases.*—The leading article in the Annalen der Physik und Chemie, No. 11, 1884, is upon the validity of Maxwell's formula for viscosity. The author, Hr. Otto Schumann, sums up the results of his late investigation as follows:

(1) Maxwell's formula gives under certain conditions, and at higher temperatures, discrepancies which cannot be accounted for by faults of observation.

(2) By means of a coëfficient of correction Maxwell's formula can be made to give at ordinary temperatures results which agree well with the transpiration method.

(3) The transpiration method gives, on account of absorption, too large values for the viscosity of gases at higher temperatures. The results for steam are too small.

(4) The dependence of the viscosity upon the temperature increases with the same.

(5) The coëfficients of viscosity of all vapors investigated by the author have approximately the same temperature function.

(6) Puluj's relation between wave-lengths and index of refraction increases for the vapors of homologous ethers with the corresponding temperatures.—*Ann. der Physik und Chemie*, No. 11, 1884, pp. 353–403. J. T.

2. *Distribution of electric lighting over great distances.*—At the late International Electrical Exposition in Turin a committee reported upon this subject. M. Tresca gives the results reached by this committee in a communication to the French Academy. MM Gaulard and Gibbs established between the station of Lanzo and intermediate stations a circuit, of which the total length, including the return circuit, was 80 kilometers. The wire was a chrome bronze 3·7 millimeters in diameter and uncovered. The current was an alternating one, produced by a Siemen's dynamo of 30 horse-power type, and the circuit was arranged so that the electrical energy could be utilized simultaneously by different methods of lighting in the exposition building, in the station at Turin, at Lanzo, or at intermediate stations. This utilization was accomplished by means of secondary generators of peculiar construction, which have been devised by MM. Gaulard and Gibbs.

On the 25th of last September there was in regular operation the following apparatus:

(1) At the exposition building 9 Bernstein lamps, 1 Soleil lamp, 1 Siemen's lamp, 9 Swan lamps and 5 other Bernstein lamps at a short distance. All of these lamps required different potentials.

(2) At the station of Turin-Lanzo, distant 10 kilometers, 34 Edison lamps of 16 candle power; 48 of 8 candle power, and one Siemen's arc light.

On the 29th of September the system included the station of Lanzo, distant 40 kilometers, where 24 Swan lamps, requiring 100 volts, were maintained with perfect regularity. The number of transformations which diverse methods of lighting require can be effected by means of a system of secondary generators, which permit of the transmission of the electrical energy produced by alternating machines to a distance of at least 40 kilometers (about 24·2 miles).—*Comptes Rendus*, Oct. 6, 1884, p. 549. J. T.

3. *Heat and Electricity.*—F. KOHLRAUSCH has supported the theory that the phenomena of thermo-electricity result from the interchange of heat and electricity, the one carrying the other and interchanging energy. This theory has been called the *Mitführungstheorie.* Budde acknowledges that this theory explains many of the phenomena of thermo-electricity, and shows how the theory can explain the relation between the thermo-electric force and the difference of temperaturé of the thermo-electric junctions; but he discovers in the principles of thermo-dynamics objections to the conveyance theory. Kohlrausch does not urge any crucial experiment, for none exists which can test the truth of the contact theory or the conveyance theory.

Budde urges as an objection to the conveyance theory that in order to agree with the second law of thermo-dynamics it requires that the phenomenon of the thermo-electric chain should be expressed by means of a quadratic expression as a function of the temperature. Kohlrausch shows that Avenarius, Tait, Ammann and himself had been led to this quadratic expression. Budde does not believe that the results obtained by these investigators will be true at higher and lower temperatures. Kohlrausch in turn remarks that the metals when changed through great ranges of temperature cannot be considered as the same metals. The principal objection of Budde against the theory that electricity carries heat with it and that there is a constant interchange between electricity and heat in thermo-electric phenomena, lies in this, that one can perceive that there should be differences of distribution of heat when there are differences of heat level; but it is difficult to perceive that there should be an electrical current where there is no such difference. Kohlrausch remarks that in a pipe which conveys steam no difference of temperature is necessary in order that heat can be conveyed from one place to another by a difference of pressure. The conveyance of heat by electricity is conceivable, and this conveyance can be supposed to take place unequally in different substances. Kohlrausch believes that the *Mitführungstheorie* and the contact theory do not exclude each other, and that they may both be appealed to to explain thermo-electricity.—*Ann. der Physik und Chemie*, No. 11, 1884, pp. 477–481. J. T.

4. *Thermo-electric relations of amalgams.*—The peculiar character of mercury makes it very suitable for a standard of electrical resistance, and C. L. Weber urges its employment as a standard metal of reference in thermo-electricity instead of lead,

or pure silver. No thermo-electric current has been shown to exist between unequally heated portions of pure mercury. The author has investigated the thermo-electric relations between amalgams of mercury and other metals, and finds the following thermo-electric series for amalgams of 0·5 portions by weight of the following metals with 100 parts of mercury: tin, silver, lead, zinc, cadmium, bismuth.—*Ann. der Physik und Chemie*, No. 11, 1884, pp. 447–476. J. T.

5. *Elementary Text-book of Physics;* by Professors WILLIAM A. ANTHONY and CYRUS F. BRACKETT. Part I, 246 pp. 8vo. New York, 1884. (John Wiley & Sons.)—The appearance of a new text-book of Physics at this time is a matter of some importance. The rapid recent development of the subject in its various departments has served to make the older books antiquated and unsatisfactory, and many teachers will have been perplexed by the inability to find a work suited to the special needs of their instruction. To what extent the volume now offered will satisfy them will depend somewhat upon the character of the instruction they desire to give. Part I includes in Book I the Introduction and the development of the subject of Mechanics, embracing the mechanics of masses, universal gravitation, molecular mechanics and the mechanics of fluids. Book II is devoted to the subject of Heat. The remaining departments of Electricity and Magnetism, Acoustics and Optics are to follow in Part II. So far as can be judged from the portion of the work issued, it has some good features which will commend it to those interested, but it is not hard to find points to criticize. The subject matter is often difficult and the discussion of many topics is too general to be easily grasped by a beginner; more difficult, in fact, than is entirely consistent with the size and apparent object of the book. The learner is told that only simple mathematics are required, and yet he is soon introduced to the differential coefficient, and expected to understand the idea of summation. The nature of heat is regarded as satisfactorily explained by the statement that it is "a form of energy," and yet nothing is given in the earlier part of the volume from which the student can learn what the term energy embraces, or what the different forms of energy are, nor is the principle of the conservation of energy discussed. Certainly an elementary text-book which does not at the outset explain the fundamental principle of modern physics is very incomplete.

6. *Indexes to Chemical Literature.*—The Committee on Indexing Chemical Literature, consisting of Professors H. Carrington Bolton (Chairman), Ira Remsen, F. W. Clarke, Albert R. Leeds, Alexis A. Julien, presented a report at the last meeting of the American Association for the Advancement of Science. This report gives a list of indexes already published, with the name of the compiler and the place of publication. The list includes indexes to the literature of the following subjects: Uranium, manganese, titanium, vanadium, ozone (1875–1879 and 1879–1883),

peroxide of hydrogen (1818–1878), electrolysis (1784–1880), speed of chemical reactions, starch sugar, peroxide of hydrogen, dictionary of the action of heat upon certain metallic salts including an index to the principal literature upon the subject.

The committee also announces that indexes have been offered, or are in progress of preparation, by different gentlemen, to the literature of the following subjects: carbon monoxide, meteorites, arsenic, explosives, phosphorus, uranium (a second index).

In conclusion, the committee announces that, in consequence of their representations, the Smithsonian Institution has consented to publish Indexes to Chemical Literature which shall be endorsed by this committee. The Smithsonian places a limit to the number of pages which will be printed per annum, but the limit is a generous one. By thus securing the assistance of the Smithsonian Institution, chemists are assured of a reliable and authoritative channel of publication, together with a wide circulation, and the plan of coöperative indexing will undoubtedly receive a great stimulus. It is also stated that a limited number of the indexes published by the New York Academy of Sciences can be had by addressing the Chairman of the Publication Committee of the Academy, Professor D. S. Martin, 236 West 4th street, New York City.

II. Geology and Mineralogy.

1. *Geology of the Scottish Highlands.*—The important paper of Prof. Archibald Geikie, Director of the Geological Survey of Great Britain, reprinted from Nature, of Nov. 13, on pages 10 to 15 of this number is followed by a special report on the *Geology of the Northwest of Sunderland* by the geologists of the Survey whose work called forth that paper, Messrs. B. N. **Peach** and **John Horne**, the former in charge of the investigation. The results, besides settling a question in Scottish geology that has been long under discussion, illustrate a principle in geological dynamics, that of lateral-thrust in great displacements, which is of the highest importance. We cite the stratigraphical section of the report, with a few accompanying paragraphs, referring to the original article in Nature for the rest of the details.

"As the observer passes eastward along the magnificent quartzite sections on Crag Dionard and Conamheall, south of Loch Eriboll, he cannot fail to note the numerous flexures of the strata, and especially the peculiar type of their sharp anticlinal folds. As a rule, the eastern limb of each of these folds dips at a gentle angle to the southeast, while the west limb is highly inclined, vertical, even inverted, or sometimes broken by a reversed fault, the effect of which is to bring lower over higher beds. These reversed faults (*t t t* in Section) become more numerous eastward. They are admirably displayed both in ground-plan and dip-section on the shore north of Heilim, where they repeat the various zones ranging from the "pipe-rock" to the Eilan Dubh limestone (Group II.). The strike of the reversed faults ranges on the whole with that of the strata traversed, and their hade is inclined at a higher angle than the dip of the latter, the difference generally amounting to about 10°. Inland from the coast-section, north of Heilim, to the base of Ben Arnaboll, the zones just mentioned are constantly repeated by a complicated system of reversed faults and folds, the general inclination of the strata being toward the southeast. As that hill is approached, the displacement produced by these faults increases in amount; hence the observer meets with beds occupying a lower geological horizon the farther east he travels. At length this intricate system of faults and folds culminates in a great dislocation which, for convenience of description, and to distinguish it from the ordinary reversed faults, may be termed a *thrust-plane.* By means of it a great mass of coarsely crystalline gneiss with pegmatite-veins, in places upward of 400 feet thick, is placed above the Silurian rocks (see Section). A careful examination of the mass which caps Ben Arnaboll clearly proves that *it rests transgressively on all the zones of the Silurian rocks, from the lower zone of the quartzite (false bedded grits) up to the limestone which overlies the Serpulite-grit.* Owing partly to its low hade and partly to subsequent folding, the outcrop of this thrust-plane resembles that of an ordinary overlying formation cut into a sinuous line by denudation. It is admirably seen in dip-section on the east and north slopes of Ben Arnaboll, whence it can be followed round the west face of the hill, descending into the

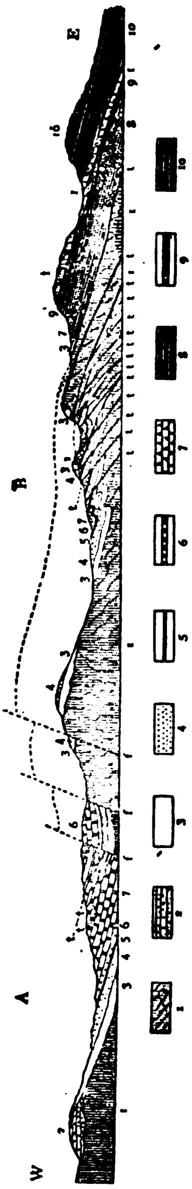

DIAGRAM-SECTION OF DURNESS-ERIBOLL REGION.

10. Gneissose Flagstones, etc. }
9. Siliceous Schist .... } NEWER GNEISS.
8. { Frilled Schist ....
   { Green Schist ....
7. Durness-Eriboll Limestone—Upper Series }
6. Serpulite-Grit .... } Middle " } LOWER SILURIAN SERIES.
5. Fucoid-Beds ....
4. Piped Quartzite .... } Lower "
3. { False-Bedded Quartzite ....
   { Basal Breccia ....
2. Sandstones and Conglomerates—"CAMBRIAN."
1. Gneiss, Granite, Pegmatite, &c. } ARCHÆAN GNEISS.

A — Durness Area; B — Eriboll Area; ff — Normal Faults; tt — Reversed Faults and "Thrust-planes." Dotted lines — continuation of normal faults and thrust-planes.

valley on the west, then bending back on itself, winding round the north slope of Druim Tungi, and entering Loch Eriboll in Heilim Bay. It reappears at the base of Crag-na-Faolinn, and has been traced still farther to the south, while northward it can be followed to the Whitten Head, at the mouth of Loch Eriboll.

That the gneiss thus brought up on Ben Arnaboll and elsewhere is in reality the Archæan gneiss is evident, for two reasons. First, its lithological characters agree with those of the typical Archæan area to the west, save in certain cases where the original features have been effaced by the crushing to be afterwards described. Near the thrust-plane, this effacement is complete, but in the heart of the mass the normal characters of the Archæan rocks, including in some instances their characteristic northwest strike, are retained. The rocks consist of coarsely crystalline hornblendic gneiss and pink granitoid gneiss, with lenticular veins of hornblende-rock and kernels of cleavable hornblende, while massive veins of pink pegmatite are well developed. The soft greenish mineral (agalmatolite?) already mentioned as characteristic of the gneiss, where now or lately covered with quartzite, occurs here in the pegmatites, and veins of epidosite are abundant. Second, at various localities the brecciated conglomerate and false-bedded quartzite at the base of the Silurian strata are found resting on these crystalline rocks. Further, the unconformable junction can on one line be traced continuously for more than a mile. There can be no doubt, therefore, that this mass is really a fragment of the old platform of Archæan rocks on which the Silurian strata were deposited.

But all these evidences of displacement are merely the precursors of a still more powerful thrust-plane, which has been traced continuously from the shore east of Whitten Head to the crest of Crag-na-Faolinn, and at intervals for many miles to the southward into the Assynt country. . . . .

One final feature of the Durness and Eriboll area remains to be noticed. The geological structure of this region has been further complicated by the subsequent folding of the strata, and by a double system of normal faults (*f f* in Section) which affect the strata and thrust-planes alike. One set of normal faults trends north-northeast and south-southwest, while another, which appears to be newer, trends more or less at right angles to these. By these two systems of later dislocations, the thrust-planes with their low hade have been intersected and shifted precisely as if they had been ordinary boundary-planes between two geological formations. Much of the difficulty, indeed, which has been from the first experienced in unraveling the complicated structure of this region may be traced to the effect of the intricate network of reversed and normal faulting. The very preservation of the Durness Basin is due to two normal step-faults, one of which lets down the quartzites more than 1,200 feet, while the other brings the whole Silurian Basin down to the sea-level."

2. *On a Chart of the ancient drift and glaciers of the northern Swiss Alps and Mt. Blanc Chain;* by M. ALPHONSE FAVRE (Geneva Archives des Sci., for Nov. 15).—Professor Favre states that this chart, prepared by him, shows by means of colors, the outlines of the névé and the true glacier of seven old glacier basins—those of the Rhine, the Linth, the Reuss, the Aar, the Rhone, the Arve, and the Isère, besides the névé and glaciers of the Jura and the outlines also of the modern glaciers. The author uses the positions of glacial scratches and of isolated bowlders, as well as moraines, for fixing the outlines of the old glaciers; and he opens with a remark on the good effect of the "Appel aux Suisses" by Messrs. Studer and Soret, and himself, made in 1867, in behalf of the protection of the more remarkable bowlders. He alludes to the barrier made by the terminal moraine between the extremities of the lateral moraines, and the effect in making lakes, some of which were great lakes in the era of the flood from the melting glacier. This was the case below Soleure, where the waters of the Aar were stopped by four great Valaisan moraines, and made a lake over 60 miles long. He points out how the map may be used for deducing the thickness and pitch of the glacier along the several valleys, and illustrates it by examples from the old glaciers of the Aar and Reuss.

The following table contains the heights, thickness, and other facts connected with the glacier of the Aar, at the Ewig Schneehorn, on the left bank of the glacier of the Lauteraar, where the glacier's height was 3000 meters; at Juchliberg, at the extremity of the left bank of the same glacier; at the Stampfhorn, below the Ritzlihorn on the east side; at the Brienzberg, south of the extremity of Lake Brienz; near Wimmis, where the glacier of the Simme encountered the glacier of the Aar; and at Gurnigel, 10 miles below Wimmis. The heights and distances are in meters; and in columns 4, 5 and 6 the numbers have reference to the interval between the consecutive localities.

	Upper glac. level.	Level of valley.	Thickness of glacier.	Distance.	Descent.	Surf. pitch for 1000 m.
1. E. Schneehorn, ...	3,000	2,747	263	11,000	500	45
2. Juchliberg, ...	2,500	1,874	626	5,500	250	45
3. Stampfhorn, ...	2,250	1,363	887	24,000	750	31
4. Brienzerberg	1,500	570	930	32,000	150	5
5. Wimmis	1,350	634	716	16,000	30	2
6. Gurnigel	1,320	597	723			

In the valley of the Grimsel the thickness of the glacier was accordingly 626 meters; and in that of the Hasli, 887 meters; and at the Brienzerberg, 930 meters, not counting the depth of the lake. The glacier of the Simme, which had near Erlenbach a height of 1350 m. above the sea, joined that of the Aar 7000 m. below, near Wimmis, giving both for some distance the same level, 1350 m.

A similar table is given for the glacier of the valley of the Reuss, which commenced at the highest point of Saint Gothard, as follows:

	Upper glac. level.	Level of valley.	Thickness of glacier.	Distance.	Descent.	Surf. pitch for 1000 m.
1. Wyttenw. Stock	3,084	2,190	894	45,000	1,724	38
2. Eggberg	1,360	437	923	13,000	0	0
3. Gotthardli	1,360	437	923	7,000	280	40
4. Rossberg	1,080	417	663	30,000	180	6
5. Lindenberg	900	409	491	26,000	100	4
6. Lägern	800	366	434	11,000	275	25
7. Reinerberg	525	330	195	6,000	25	4
8. Bottenberg	500	323	177			

Professor Favre remarks on the gentleness of the pitch over all the old Swiss glaciers. The glacier's height at Morcles below Saint Maurice, in Valais, was 1650 m., and at Chasseron on the Jura, near d'Yverdon, 1352 m., indicating a descent over the Swiss plain, of 298 m. in the 78 km. or 49 miles, between the two places, equivalent to 4 : 1000. At Chasseral, 57 km. to the northeast, the glacier's height was 1306 m., and at Mt. Salève, near Geneva, 92 km. from Chasseron, it was 1308 m.; and hence, over a distance of 149 km. across the plain, the surface was horizontal. The thickness of the glacier at Chasseron was 917 m. and at Chasseral about 871 m.

Professor Favre also speaks of the wide difference in some cases between the limits of the modern and the ancient hydrographic basins and course of drainage.

3. *Description of Geological Sections crossing New Hampshire and Vermont;* by Professor C. H. HITCHCOCK. 34 pp. 8vo, with two plates of geological sections. Concord, N. H., 1884.—These sections, by Professor Hitchcock, are the results of new field-work across the States of Vermont and New Hampshire since the New Hampshire Geological Report was published, and have much value. Professor Hitchcock here makes, as he had before announced, the Taconic slates of Emmons, south of Middlebury, to be Lower Silurian in age, and not older than the Trenton or the later part of the Trenton (the Hudson River or Lorraine division). The quartzyte is regarded as the Potsdam sandstone, and as overlying unconformably the Green Mountain rocks farther east.

The writer's opinion as to the existence of Archæan rocks in southern Vermont is mentioned, and he therefore here states that he has found evidence of the existence of isolated Archæan areas there, but that his examination of the beds of Mt. Mansfield lead him to doubt the Archæan age of a large part of the Green Mountains. J. D. D.

4. *The Till-ridge of New Haven, called Round Hill.*—Professor W. M. Davis, in his paper on Drumlins (this Journal, xxviii, 413, 1884), objects to the view that the material of Round Hill was deposited by waters descending a crevasse or knot of crevasses in the glacier (this Journal, xxvi, 358, 1883), on the ground of the absence of stratification. Bearing on this point I would recall the facts: that a broad trench or valley 40 to 60 feet deep (120 to 130 feet above the sea-level, and 170 to 180 below the summit of the hill), extends half-way around the hill, and is cut

out of the rocks to that depth; that from the bottom of the till of the ridge the pitch to tide-level, three-fourths of a mile off, is nearly 200 feet and from the top 300 feet. If the deposition took place after the subsidence that opened the Champlain period, a pitch of 200 feet in three-fourths of a mile, or 266 feet in a mile, would be reduced to 230 feet a mile. The difficulty in the explanation does not come from the absence of regular stratification, but from the existence of enough sand and clay in the hill-deposits to bind the stones together. Evidence of the violent action of the descending waters is plain enough about the hill in the valley described, and also in the bare rocks of the hills to the northeast, east and southeast of it, whose height is near that of the bottom of the till; for some reason they left the small area of the hill for the accumulation of the deposited material.

J. D. D.

5. *The Copper-bearing rocks of the Lake Superior region.*—In a notice of Professor Irving's report on these rocks in the last volume of this Journal (p. 462), the view of the author is stated as to their relations to the Annimikie group on the north shore of Lake Superior, and the Lake Superior sandstone, that (1) the Annimikie group is Huronian; (2) that the Keweenaw series is overlaid unconformably by the "Eastern Lake Superior sandstone;" (3) that the latter is probably Potsdam in age, as held by most geologists "from Owen to Rominger;" (4) that the unfossiliferous Keweenaw series may be older Cambrian.

We add here the views of Professor N. H. Winchell, Geologist of Minnesota, on the same points, as given in the 10th Report (1881), of the Geological Survey, and noticed in the Appendix of Professor Irving's Report. On the first of these points they are the same as above. On the second, or the unconformability of the copper-bearing rocks and the overlying series, there is agreement also; as stated on page 123, "at different places No. 1 [the light-colored sandstone seen in the Mississippi river bluffs and the bluffs of the St. Croix, containing Lingulæ and trilobites], and 2 [the horizontal sandstones of the south shore of Lake Superior, holding fucoids and Scolithus], have been seen unconformably overlying portions of No. 3 [the copper-bearing series or so-called Keweenaw formation]." On the third, Professor Winchell holds, from the fossils of the Eastern sandstone and the St. Croix beds, that the group probably belongs above the Potsdam sandstone, though Professor Hall refers the St. Croix fossils to that period. On the fourth point he makes the copper-bearing rocks equivalents of the Potsdam series.

The argument for the last-mentioned conclusion is largely lithological and therefore of little or no weight. That from the fossils in the slates and sandstones of St. Croix is indecisive, as remarked by Professor Irving, since the precise age of the fossils, whether Potsdam or later, is not certain. The Lingulæ of the sandstones of Tequamenon Bay, found by Rominger, which led him to refer those sandstones to the Potsdam, Professor Winchell says make the Keweenaw series Potsdam, *if* the rocks are equivalents.

Mr. Wadsworth's discussion of the subject will be found in his memoir on the Iron and Copper Districts of Lake Superior, in vol. i, of the geological series of the Museum of comparative Zoölogy.

6. *The Geological and Natural History Survey of Minnesota.* The 12th Annual Report, for the year 1883, N. H. WINCHELL, State Geologist.—This Report contains a paper on the comparative strength of Minnesota and New England granites, by N. H. Winchell. The experiments were made on 2-inch cubes unpolished and appear to have been conducted with care. The average strength in pounds of 20 samples of Minnesota granites, crushed between steel plates, was found to be 104,800 pounds, or 26,200 per square inch of surface; when crushed between wooden cushions, 93,272 pounds, or 23,318 pounds per square inch. The tests were applied by Mr. James Cocroft, under the direction of Gen. Q. A. Gilmore.

The average obtained by Gen. Gilmore for 20 New England granites (in 1875) was 59,785 pounds, or 14,946 pounds per square inch.

The Minnesota granites are Archæan. How far this is the fact with those of New England is not known. An explanation of the differences might be obtained by an investigation into the relative porosity of the rocks, or their absorbent quality, the amount of mica, the presence of which fissile and feebly adherent mineral must always diminish strength, and other textural differences.

Following this report on granites the volume is occupied by a final report on the Crustacea of Minnesota, included in the orders Cladocera and Copepoda, by C. L. Herrick, assistant in zoology, which extends to 192 pages, contains a large number of new forms, and is illustrated by numerous plates. This extended memoir contains also "a synopsis of the described species in North America, and keys to the known species of the more important genera."

7. *Report of the Geological Survey of Ohio*, Vol. v. *Economic Geology;* EDWARD ORTON, State Geologist. 1124 pp. 8vo. Columbus, Ohio, 1884.—The various economical products from the rocks of Ohio are the subjects treated in this large volume, The stratigraphy and characteristics of the Coals, Iron Ores. Building Stones, Clays, and the methods of working and the industries connected therewith, are first reviewed at length, and then special reports added on the coal beds of different regions in Ohio. Besides Professor Orton, there are among the authors on these subjects, A. Roy, Inspector of Mines; N. W. Lord on the Iron manufacture, H. Newton on the manufacture of Coke; Edward Orton, Jr., on the clays and their industries; E. McMillin, on Gas Coals; and for the special reports on coal regions, A. A. Wright, C. N. Brown and E. Orton, Jr. There is also a

report on analyses of Coals, etc., by N. W. Lord; and another on the Glacial boundary in Ohio, by Prof. G. F. Wright. The volume is illustrated by many sections and maps. It is a valuable contribution to economical geological science.

8. *Contributions to the Tertiary Geology and Paleontology of the United States;* by ANGELO HEILPRIN, Prof. of Invert. Paleont. at, and Curator in charge of, the Acad. Nat. Sci., Philad. 118 pp. 8vo, with a colored geological map, showing the distribution of the several divisions of the Tertiary along the Atlantic coast and around the Gulf of Mexico.—This volume consists of the collected papers of Mr. Heilprin on the United States Tertiary, published by the Philadelphia Academy of Sciences, emended in some points, with new papers by him on the same general subject. The Tertiary paleontology of North America has needed a thorough revision in order to reconcile discrepancies between the results of different authors, correct references to localities, add further facts as to true stratigraphical order, and make full comparisons and all necessary identifications with the described species of the foreign Tertiary. Mr. Heilprin has been working in these directions, and has brought out a volume of great service to American geology, although much still remains to be done. His classification of the American marine Tertiary has already been given in this Journal, vol. xxiv, p. 228, 1882.

9. *Report PPP of the Geological Survey of Pennsylvania on Devonian Ceratiocaridæ,* by C. E. BEECHER, with 2 plates, and *on Carboniferous Eurypteridæ,* by JAMES HALL, with 6 plates.—Mr. Beecher describes new species of the genera *Echinocaris, Elymocaris* and *Tropidocaris,* the two latter genera being also new. The number of species of the group reached its maximum, according to the investigations thus far made, in the Chemung period. Prof. Hall describes the new species *Eurypterus Beecheri* and *E. stylus.*

10. *On the Structure and Affinities of the Receptaculidæ;* by Dr. G. J. HINDE. (Jour. Geol. Soc., 1884, 795.)—Dr. Hinde discusses with great fullness the structure and relations of these singular fossils, and concludes that they belong with the siliceous hexactinellid sponges. The body walls, he observes, are composed of spicules of the hexactinellid type, but modified by the development of regular rhomboidal or hexagonal plates in place of the head ray of the normal spicule. The family is represented in the Lower and Upper Silurian, sparingly in the Devonian, by a single doubtful species in the Carboniferous (described by F. Römer, from Silesia beds), and not in later rocks.

11. *Paleozoic Corals. Spitzenbergen fossils.*—G. Lindström has an "Index to generic names applied to the corals of the Paleozoic formations" in the Handlingar of the Swedish Royal Academy, vol. viii, No. 8, 1883.

The same volume contains a paper, by B. LUNDGREN on the Jurassic and Triassic fossils of Spitzbergen, collected by the Swedish Expedition of 1882; and also another, by TH. FUCHS, on the Tertiary shells of Spitzbergen, from the same collections. The Tertiary shells include species (not satisfactorily determinable) of *Siliquaria*, *Pharella*, *Psammosolen* and *Venus* (*Circomphalus*), from the lower horizon near Kolbay, and *Cytherea* (Callista), and *Psammobia* from the upper, at Advent Bay, all unknown from the Arctic seas; also a *Thracia*, larger than the largest known. He observes that the species appear to be Miocene, or later rather than earlier; and that they do not sustain the view put forward by Gardener that the era of the Polar flora was Eocene instead of Miocene.

12. *Geology of Delaware.*—Professor F. D. CHESTER has a paper on the geology of the State of Delaware in the volume of the Proceedings of the Academy of Natural Sciences of Philadelphia for 1884, pp. 237–260.

13. *Lower Silurian age of the Peach Bottom roofing slates of York and Lancaster Counties, Pennsylvania.*—Dr. P. FRAZER has found fossil plants in these roofing slates and probable fragments, in Prof. James Hall's judgment, of graptolites, which point to the Hudson River or Quebec group age of the slates. The locality is on the Lower Susquehanna. The rocks are much tilted, and near the slates, and apparently above them occurs a quartz-slate, containing, like the Chikis quartzyte, intercalated hydromicaceous beds. They are among a series of chloritic schists.

14. *Paleozoic Arachnida.*—Mr. S. H. SCUDDER has published a revision of the subdivisions of fossil Arachnids in a paper in the Proceedings of the American Academy of Arts and Sciences, 1884, p. 13, in which he describes the new genera *Poliochera*, *Geraphrynus* and *Geralinura* for Mazon Creek species, and the new species *Anthracomartus pustulatus*, from the same locality; also *Anthracomartus trilobitus* from the sub-conglomerate coal-measures near Fayetteville, Arkansas.

15. *Professor E. D. Cope on fossil Vertebrates.*—Professor Cope has recently published the following papers:

The North American Batrachia, Amer. Nat., January, 1884.

Synopsis of the Species of the Oreodontidæ, Amer. Phil. Soc., January, 1884.

Structure of the skull in the Elasmobranch genus Didymodus, Amer. Phil. Soc., March, 1884.

The Creodonta, Amer. Nat., March, 1884.

The Tertiary Marsupialia, Amer. Nat., July, 1884.

The Extinct Mammalia of the Valley of Mexico, Amer. Phil. Soc., May, 1884.

The Mastodons of North America, Amer. Nat., May, 1884.

On the Structure of the feet in the extinct Artiodactyla of North America, Ibid., August, 1884.

Fifth contribution to the knowledge of the Fauna of the Permian formation of Texas and the Indian Territory, Amer. Phil. Soc., August, 1884.

16. *Note on Brazilian Minerals;* by ORVILLE A. DERBY.—In

an examination of the heavy sands accompanying the diamond at the newly discovered washings of Salobro or Canaviciras, near the mouth of the Jequelinhouba in southern Bahia, Professor Gorceix notes the absence of the oxides of titanium (rutile and octahedrite), of the hydrous phosphates of alumina and cerium, and of tourmaline, so characteristic of the diamond sands of Diamantina, Bagagens, and of the diamond region of Bahia. These sands are remarkable for containing monazite (the most abundant mineral after quartz), zircon, staurolite and corundum. The last two are noted for the first time among the minerals accompanying the diamond, and the last, corundum, for the first time definitely, in Brazil. Zircon, which is quite abundant, had been found rarely in the diamond sands of Bahia by Damour but never in those of Minas, while monazite had only been found rarely in a single locality in the Diamantina district.

Prof. Gorceix has also studied the *favas* (Lima beans) of the miners which are very characteristic of the diamond deposits of Diamantina and western Minas Geraes. These are discoid pebbles resembling in shape the seed from which they take their name, which decrepitate and give much water in the closed tube. Three series are recognized, two of which contain silica, alumina and a small proportion of phosphoric acid. The other more interesting series, of which the analysis has not yet been completed, contain titanic, phosphoric and vanadic acids, and the bases alumina, lime, iron, cerium, yttrium and didymium.

Christianite has been recognized by the same author in a decomposed pyroxenic rock from the head-waters of the Abaete, a western tributary of the upper San Francisco. The following analyses are given.

	No. 1.	No. 2.
SiO_2	47·5	46·9
Al_2O_3	20·6	21·5
Fe_2O_3	1·1	2·4
CaO	7·6	7·0
MgO	3·1	2·3
KO	4·4	4·6
NaO	0·8	1·6
HO_2	15·0	15·0
	100·1	101·3

—*Annals du Escola de Minas de Ouro Preto,* vol. iii.

17. *Spodumene crystals of gigantic size;* by WILLIAM P. BLAKE. (Communicated.)—The excavations upon the Etta tin mine in Pennington County, Dakota, have exposed numerous crystals of spodumene of unusually large dimensions. One crystal which extends horizontally parallel with a drift is thirty-six feet in length in a straight line, and is from one to three feet in thickness. It penetrates massive quartz and feldspar. The cleavage is smooth and straight, but the lateral and terminal planes are obscure. Crystals from five to twenty feet long are numerous and incline in all directions.

18. *Minerals from Kangerdluarsuk in Greenland.*—A paper recently published by Dr. Lorenzen, of Copenhagen, contains analyses and crystallographic notes on several minerals from Kangerdluarsuk in Greenland; an earlier paper by the same author has already been noticed (this Journal, xxv, 158). The name *Rinkite* is given to a mineral occurring in monoclinic crystals with arfvedsonite, ægirite, eudialyte, etc. Its color is yellowish brown when fresh, but the crystals are often altered so as to have an earthy structure and straw-yellow color. The hardness is 5, the specific gravity 3·46. The mean of several analyses yielded:

SiO_2	TiO_2	$\underbrace{\text{CeO DiO LaO}}$	YO	FeO	CaO	NaO	Fl
29·08	13·36	21·25	0·92	0·44	23.26	8·98	5·82

=103·11, deduct 2·45 O = 100·66

For this the formula proposed is $2\overset{II}{R}\overset{IV}{R}O_3+NaFl$, although the correctness of the formula is not fully established. The name *Polylithionite* is given to a variety of lithia mica unusually rich in lithium. An analysis gave:

SiO_2	Al_2O_3	FeO	K_2O	Na_2O	Li_2O	Fl
59·25	12·57	0·93	5·37	7·03	9·04	7·32 =

102·11, deduct 3·08 O = 99·08

In optical relations this lithia mica stands very near zinnwaldite but is remarkable in containing more silica; this, the author states, cannot be due to impurity.

19. *Synopsis Mineralogica:* Systematische Uebersicht des Mineralreichs, entworfen von Dr. Albin Weisbach. Zweite Auflage, 87 pp. 8vo. Freiberg, 1884. (J. G. Engelhardt.)—This work contains a list of mineral species with a statement of their composition, and in most cases, the crystalline system to which they belong; the system of classification is rather artificial.

III. Botany and Zoology.

1. *Comparative Anatomy of the Phanerogams and Ferns;* by Dr. A. DeBary, Professor in the University of Strassburg. Translated and annotated by F. O. Bower, M.A., F.L.S., and D. H. Scott, M.A., Ph.D., F.L.S. (Clarendon Press, Oxford, 1884; pp. 659.)—DeBary's Vergleichende Anatomie has been in the hands of students since 1877. It has been everywhere recognized as the most exhaustive work on the subject hitherto published, but owing to this very fact and to its extremely technical character, we had almost despaired of seeing it in print in English. A manuscript translation prepared four years ago by Miss Mary Chapman, of Boston, has done good service in the Botanical Laboratory, in Cambridge, and has made known to not a few students, unfamiliar with German, the excellencies of DeBary's treatise. From what the present writer has seen of

the pleasure with which even a manuscript translation has been employed, he feels sure that the well printed and convenient translation which now comes to us will have many more appreciative students than the publishers have looked for.

Professor DeBary, in the preface, complains of the patchwork character of parts of the volume. He says that he had hardly finished one portion before those preceding it were out of date, and by remodelling, such portions necessarily lost something of their due proportion. But this is true of all encyclopedic treatises, and serves to indicate the magnitude of the work which DeBary has so well done.

The treatise is in two parts: (1), Forms of tissue; (2), Arrangement of the forms of tissue. The classification adopted in the first part is as follows: *Cellular tissue*, including epidermis, cork and parenchyma; (2), *Sclerenchyma*, comprising so-called "hard bast;" (3), *Secretory reservoirs*, or sacs; (4), *Tracheæ*, including Tracheids; (5), *Sieve-tubes;* (6), *Laticiferous tubes*. The account of intercellular spaces is placed properly in an appendix. Under ARRANGEMENT of these tissues, the author considers the occurrence of each kind in all classes of vascular plants, and regards the subject largely from the point of view of development.

The amount of material which is here brought together is absolutely surprising. The references are very copious and, as we have had occasion to note in a large number of cases, given without serious error in citation of volume or page. Although a part of the work of compilation must have been irksome in the extreme, it has been thoroughly and carefully done, and the treatise will long remain the most valuable digest of vegetable histology.

The translators have given us a good version. Here and there exception might be taken to their readings, but they are chiefly minor points which do not seriously impair the value of the hand-book. Almost unqualified commendation can be given to the translation for its fidelity, and, what is better, its clearness. The annotations add much to the value of the work and bring portions of the subject down to a recent date. Lastly, it should be said that the index is a marvel of completeness and accuracy, and places this encyclopedic treatise, which is crowded with details, perfectly at the service of the student. G. L. G.

2. *Living organisms in the air at high altitudes.*—A paper by M. E. DE FREUDERICH, on the number of living organisms in the air about the Swiss Alps, is published in the Geneva Archives des Sciences for November last (Nov. 15). He shows that the observations of Pasteur and Tyndall, as far as relating to this special point, are unsatisfactory because the germs are not destroyed at the temperature of ebullition, but require 110° C., and because the amount of air thus examined by the method they used was very small—hardly more than half a liter, he says, in Tyndall's experiments. Mr. Freuderich, in order to make his trials on a large volume of air, used first a hand air pump, which passed a

liter of air at each stroke of the piston, and in more recent trials, a portable steam pump which, under a pressure of two atmospheres, could move 2500 to 3000 liters an hour. The mean amount used was 150 liters an hour. The organisms were detained by a wad of spun glass in a glass tube, various precautions being used to insure accuracy. Each wad was afterward divided and each half put into a portion of beef bouillon for the development of any microbes present, in which process the bouillon became clouded. The method is one proposed by Dr. Miquel in the Annuaire de Montsouris for 1884. His trials in 1884 were made at the Theodule Pass, near Zermatt, 3322^m in elevation, above the limit of perpetual snow; on the Aletsch glacier, 2900^m; and in part at the summit of the Niesen, 2366^m, situated on the border of Lake Thun and surrounded by numerous villages.

On the Aletsch glacier, July 15–17, one trial of 500 liters of air, gave no organism; another of 800 liters, afforded one "maigre" *Bacillus subtilis;* one of 250 liters, a single organism of the family Torulaceæ; one of 50 liters, a single *Micrococcus*—about which there was some doubt. He thus obtained from 2000 liters of air, at a height of about 3000 meters, two Bacteria (a Bacillus and a Micrococcus) besides one of the Torulaceæ. In the second series of experiments, at the St. Theodule Pass, September 6, 7, one *Bacterium termo* was obtained from 3000 liters, or three cubic meters of air. In contrast with this extreme purity, the air at Berne gave him in one trial hundreds and even thousands to the cubic meter; and among the organisms in one case there were 444 microbes to the cubic meter, in another 250.

On the mountain of Niesen, in the last of July and first of August, rain, snow and a severe storm, complicated the trials. 600 liters of air, under these conditions, gave 4 Bacteria (all of one species); and in another trial, 4 Bacteria for 1725 liters. Adding the two, it makes 3 to 4 Bacteria to the cubic meter. With reference to the Bacteria being of a single species, the author states that on the plain in 1881, M. Miquel found 14 Bacilli to 79 of Micrococcus and 7 of Bacteria; and the author had a similar result at Berne.

M. Freuderich reports also other similar results from different localities, and observes that the purity of the air of the mountains is far greater than had been deduced from the trials of Pasteur and others; that it is not exceeded by the air over the ocean, from which Commander Moreau obtained (according to a communication from Dr. Miquel in the Semaine Medicale of March 6, 1884), five to six Bacteria to a cubic meter.

3. *Description of an impregnated uterus and the uterine ova of Echidna hystrix.*—Professor Richard Owen (Ann. Mag. N. H., V, xiv, 373, Dec., 1884), refers to his papers in the Philosophical Transactions of 1865 and 1880, on reproduction in the Echidna, and his account and figures in the latter paper illustrating a specimen in which the left uterus contained three ova, the largest 6^{mm} in diameter. He then gives a description and figures

of the right and left uterus, each with a collapsed ovum, of an Echidna captured near Toowoomba, in 1882. In both uteri the absence of any connection of the ova with the uterine walls was shown by their floating freely as moved by the feeble wave of the menstruum in which the dissection was made.

The paper closes with a copy of a letter from W. H. Caldwell addressed by him to the Sydney (N. S. W.) Herald, Sept. 16, 1884. Mr. Caldwell observes that in both the Ornithorhynchus and Echidna "the amount of food-yolk in the egg is very large, and that consequently, there is only a partial *segmentum* (meroblastic type)." The egg is laid at an age equal to a 30-hour-old chick, and is enclosed in a strong, flexible, white shell; it is three-quarters of an inch long in the longer diameter, and one-half inch in the shorter. Ornithorhynchus produces two eggs at a birth, Echidna, one; the former places the eggs at the end of one of the burrows, the latter her one in a ventral pouch. Mr. Caldwell states that he has already worked out most of the stages in the development, and hopes to obtain a sufficient number of specimens to complete his investigation during the present breeding season. He has also obtained, since his arrival last October, many embryos of several genera of Marsupials for study.

4. *A Polythalamian from a Salt-pool near Déva in Transylvania.*—The first known species of a polythalamian from continental waters has been described by Dr. E. von Daday. Its shell is much like that of a *Rotalia* in its spiral form; like *Trochammina* in structure; and like the *Difflugiæ* and the *Polymorphina silicea* in the constitution of its shell, it being chitinous with some siliceous scales in its texture. The author names it *Entzia tetrastomella*, and regards it as probably representing a group, along with some forms of the genus *Trochammina*, which unites the imperforate with the perforate Polythalamia, and the group of the Lagenidæ with that of the Globigerinæ. Of the associated protozoans in the salt-pools in the region, nine have hitherto been found only in saline inland waters, while ten occur both in saline inland waters and the sea, and seven of these ten are found both in fresh and saline inland waters. Dr. Daday remarks that the facts decidedly favor the opinion of Professor G. Entz, that the protozoans of the saline inland waters of Transylvania are more nearly allied to those of the sea than to those of the fresh water.—*Ann. Mag. N. Hist.*, Nov., 1884.

5. *Food of Mice.*—Professor F. H. Storer, in a paper in the Bulletin of the Bussey Institution, (vol. ii, Part iv, 1884), describes the effects of feeding mice on painter's putty (made of ground chalk (whiting) and oil, either linseed or fish oil), and putty made of other substances. They were fed with the whiting putty in balls and ate freely 10 or 12 balls (12 weighing 20 grams, of which 3·3 grams were oil) daily besides their allowance of oats. The excrements became white and chalky, free from the oil and very abundant, the quantity of chalk discharged amounting to more than one-third the weight of the animals.

A like mixture of barium carbonate or lead carbonate and oil, killed the mice; but they ate, apparently without injury, a putty made of mixed barium carbonate and whiting, in the proportion of 1 to 5, and so also a putty made of lead carbonate and whiting, in the proportion of 1 to 4. The protective influence of the calcium carbonate in these cases is, as Dr. Storer observes, a fact of much interest; and the fact that they eat common putty with relish for the oil it contains is one of public importance.

6. *Annals of the New York Academy of Sciences.*—Numbers 3 and 4 (in one) of the Annals contains an elaborate paper by W. G. **Binney** on the Jaw and Lingual Dentition of Pulmonate Mollusks, illustrated by 16 plates.

7. *Prodromus Faunæ Mediterraneæ, sive Descriptio Animalium Maris Mediterranei Incolarum*, quam comparata Silva rerum quatenus innotuit adjectis locis et nominibus vulgaribus, eorumque auctoribus in commodum Zoologorum congessit Julius Victor Carus. Pars. I, Cœlenterata, Echinodermata, Vermes. 283 pp. 8vo. Stuttgart, 1884. (E. Schweizerbart'sche Verlagsh. (E. Koch)).—This first part of the Prodromus contains brief classified descriptions of the animal species of the Mediterranean, belonging to the tribes stated in the title, and has been prepared by one of the best of European zoologists. It is especially convenient for the zoological laboratories on the coasts of the Mediterranean, but has great value for other seas and regions.

8. *The Auk: a Quarterly Journal of Ornithology.*—No. 4 of the first volume of this excellent journal was issued in October. Mr. E. P. Bicknell publishes in it an interesting "Study of the Singing of our Birds;" J. P. Howley a paper on the Canada Goose (*Bernicla Canadensis*); W. W. Cooke, on the distribution and migration of Harris's Finch (*Zonotrichia querula*); F. Stephens, on LeConte's Thrasher, and collecting in the Colorado Desert; J. A. Allen, on zoölogical nomenclature; besides which there are various other valuable contributions.

9. *The Siluroid fish, Amiurus catus.* — A thorough study of this species has been made by Canadian zoologists and the results are the subjects of several finely illustrated articles in the Proceedings of the Canadian Institute, Toronto, vol. ii, fasc. 3, Oct., 1884; by Professors **R. Ramsay Wright**, **J. Playfair McMurrich**, **A. B. Macallum**, and **T. McKenzie**.

10. *The Development of Renilla;* by **Edmund B. Wilson**, Ph.D., Fellow of the Johns Hopkins University. 93 pp., 4to, with 16 plates.

IV. ASTRONOMY.

1. *Abstract of a Report to the Solar Physics Committee on a Comparison between apparent Inequalities of Short Period in Sun-Spot Areas and in Diurnal Temperature-Ranges at Toronto and at Kew;* by **Balfour Stewart**, M.A., LL.D., F.R.S., and **William Lant Carpenter**, B.A., B.Sc.—It has been known for some time that there is a close connection between the inequalities

in the state of the sun's surface as denoted by sun-spot areas and those in terrestrial magnetism as denoted by the diurnal ranges of oscillation of the declination magnet; and moreover the observations of various meteorologists have induced us to suspect that there may likewise be a connection between solar Inequalities and those in terrestrial meteorology.

This latter connection, however (assuming it to exist), is not so well established as the former, at least if we compare together Inequalities of long period. It has been attempted to explain this by imagining that for long periods the state of the atmosphere as regards absorption may change in such a manner as to cloak or diminish the effects of solar variation by increasing absorption when the sun is strongest and diminishing absorption when the sun is weakest.

On this account it seemed desirable to the authors to make a comparison of this kind between short-period Inequalities, since for these the length of period could not so easily be deemed sufficient to produce a great alteration of the above nature in the state of the atmosphere.

The meteorological element selected for comparison with sun-spots was the diurnal range of atmospheric temperature, an element which presents in its variations a very strong analogy to diurnal declination-ranges.

There are two ways in which a comparison may be made between solar and terrestrial Inequalities. We may take each individual oscillation in sun-spot areas, and find the value of the terrestrial element corresponding in time to the maximum and the minimum of the solar wave. If we were to perform this operation for every individual solar Inequality, and add together the results, we might probably find that the magnetic declination-range was largest when there were most sun-spots. If, however, we were to make a similar comparison between sun-spot daily areas and diurnal temperature-ranges we might not obtain a decisive result. For at certain stations, such as Toronto, it is suspected (the verification or disproval of this suspicion being one of the objects of this paper) that there are two maxima and two minima of temperature-range for one of sun-spots. The effect of this might be that in such a comparison the temperature-range corresponding to a maximum of sun-spots might be equal in value to that corresponding to a minimum, or, in other words, we should get no apparent result, while, however, by some other process proofs of a real connection might be obtained. But if we can get evidences of apparent periodicity in sun-spot fluctuations when dealt with in a particular manner, we have at once a method which will afford us a definite means of comparison. And here, as Professor Stokes has pointed out, it is not necessary for our present purpose to discuss the question whether these sun-spot Inequalities have a *real* or only an *apparent* periodicity. All that is needful is to treat the terrestrial phenomena in a similar manner, or in a manner as nearly similar as the observations will allow, and then see whether they also exhibit periodicities (apparent or real) having virtually the same times as those of sun-spots, the phases of the two sets of phenomena being likewise allied to one another in a constant manner.

It is such a comparison that the authors have made, their method of analysis being one which enables them to detect the existence of unknown Inequalities having apparent periodicity in a mass of observations. A description of this method has already been published in the "Proceedings of the Royal Society" for May 15th, 1879. The comparison was made by this method between sun-spot observations extending from 1832 to 1867 inclusive, Toronto temperature-range observations extending from 1844 to 1879 inclusive, and Kew temperature-range observations extending from 1856 to 1879 inclusive. The following conclusions were obtained from this comparison.

(1) Sun-spot Inequalities around 24 and 26 days, whether apparent or real, seem to have periods very nearly the same as those of terrestrial meteorogical Inequalities as exhibited by the daily temperature-ranges at Toronto and at Kew.

(2) While the sun-spots and the Kew temperature-range Inequalities present evidence of a single oscillation, the corresponding Toronto temperature-range Inequalities present evidence of a double oscillation.

(3) Setting the celestial and terrestrial members of each individual Inequality, so as to start together from the same absolute time, it is found that the solar maximum occurs about 8 or 9 days after one of the Toronto maxima, and the Kew temperature-range maximum about 7 days after the same Toronto maximum.

(4) The proportional oscillation exhibited by the temperature-range Inequalities is much less than the proportional oscillation exhibited by the corresponding solar Inequalities.—*Proc. Roy. Soc.*, No. 232.

2. *Astronomical Observations and Researches made at Dunsink.* Fifth Part, Dublin, 1884.—Dr. Ball has in this volume given the result of a systematic search for stars of measurable parallax. Nearly four hundred stars were examined, with a negative result; that is, they did not indicate an annual parallax large enough to lead him to give further attention to them. The details of his measurements are given. Upon four stars, however, Dr. Ball has made elaborate measurements and obtained these parallaxes:

61 Cygni, $\pi = 0''{\cdot}4676$.
Groombridge, 1618, $\pi = 0''{\cdot}322$.
P. III, 242, $\pi = 0''{\cdot}045$.
6 Cygni, $\pi = 0''{\cdot}482$.

The parallax of 61 Cygni differs little from that obtained by Professor Hall at Washington, Professor Hall's result being $0''{\cdot}4783$. The several parallaxes of this double star obtained by Struve, Auwers, Hall and Ball indicate that the true value cannot differ much from one-half a second. The small negative parallax of P. III, 242, strictly taken implies that this star is a little more distant than the 8th magnitude comparison star, 37°, 877.

3. *Zones and Zone Catalogue of the National Argentine Observatory.*—The four quarto volumes of star positions referred to by Dr. B. A. Gould in his letter in the December number of this Journal, have been received. Two of them, vols. iii and iv, contain zone observations made in 1873, and two, vols. vii and viii, contain the zone catalogue. This extends from declination — 23° to — 80°, covering thus a zone from — 23° to — 30° which Argelander had observed near his southern horizon at Bonn, and part of the region of Gilliss's observations near the South Pole.

The whole number of stars in the Catalogue is 73,160. A few stars are entered as of the tenth magnitude, though the limit was in general the 9½ magnitude. Most of the stars were observed but once, the total number of zone observations being somewhat over 100,000. This zone catalogue constitutes the second of the three principal contributions which the Argentine Government and Dr. Gould are furnishing to astronomers. The first was the Uranometria Argentina, already published; the third is the general catalogue of stars spoken of in his letter to Professor Dana, quoted in the last number of this Journal.

4. *International Conference held at Washington for the purpose of fixing a Prime Meridian and a Universal Day, October*, 1884.—A volume of 212 pp., large octavo, has just been published containing detailed reports of the eight sessions of the International Conference, the first held on October 1st, and the last on November 1, 1884. This record is all the more valuable and interesting in view of the important results to which the discussions here printed in full finally led.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Systematic Earthquake Observations.*—On Nov. 21, 1884, a conference was held in Washington to consider and arrange a systematic plan of earthquake observation throughout the country. It was called by the Director of the Geological Survey, and there were present Messrs. J. W. Powell, C. E. Dutton, and G. K. Gilbert of the Geological Survey, H. M. Paul of the Naval Observatory, Cleveland Abbé and C. F. Marvin, of the Signal service, W. M. Davis of Harvard College and C. G. Rockwood, Jr., of Princeton College.

It was considered desirable to attempt work in two directions. First.—The collection of more reliable non-instrumental observations, by the general distribution of circulars of information and blank reports, to be filled up and returned to some central office after the occurrence of an earthquake. It is proposed to distribute these circulars as widely as possible, and Professor Rockwood was requested to prepare forms for the necessary correspondence. Second.—The establishment of stations provided with instruments for the more or less complete recording of the earth's motion. These would probably be of two grades; the more numerous ones having some simple and inexpensive form of seismoscope to record the occurrence of a shock and to mark the time as exactly as possible, while a less number of selected stations would be provided with more elaborate seismographs to record as fully as possible the details of the earth's movement. As preliminary work in this direction, Messrs. Paul, Rockwood and Marvin are to report upon the form of instruments to be adopted; and Messrs. Rockwood, Abbé and Davis are to consider the best geographical distribution of the stations; Professor Rockwood having undertaken to prepare a chart of the geographical distribution of the earthquakes which have occurred in the United States and Canada in the last twelve years as recorded in his published lists.

Besides this preparation for observational work Mr. Davis is to report upon the bibliography of recent seismology, and Mr. Paul upon instruments already employed in other countries, especially Japan; while other related topics are not overlooked. The work is to be conducted under the supervision of the U. S. Geological Survey which will attend to the executive details of the scheme. And when sufficient observations have been collected they will be put into the proper hands for Scientific discussion. C. G. R.

2. *Volcanic Phenomena of* 1883. (Die Vulcanische Ereignisse des Jahres 1883. 19. Jahresbericht von C. W. C. Fuchs.—Min. u. Petrog. Mittheil.)—The report of C. W. C. Fuchs contains as usual an account of the volcanic eruptions and earthquakes of the year. Moderate eruptions of Etna are noted during March and April, and others during the year from Vesuvius and Cotopaxi and also in Iceland, Nicaragua, Colombia and Alaska. But by far the most important outbreak was the great eruption of Krakatoa, in the straits of Sunda, on August 26 and 27.

The activity of this volcano, which formed a small uninhabited island lying between Java and Sumatra, was first reported by a passing vessel on May 20, as indicated by white clouds topping its peak and a considerable fall of ashes. It was noted from time to time during the summer by subterranean explosions, by the expulsion of ashes and by the presence of large amounts of pumice in the neighboring seas. The great eruption began on August 26 and culminated on the 27th in a grand explosion, by which a large portion of the mountain was blown bodily into the air and fell in the neighboring straits, forming there two new islands of considerable size, which however have since yielded to the eroding action of the waves. At the same time destructive eruptions of lava and ashes were taking place from the volcanoes Maha Meru, Gunung Gunter, Kandang and Papandayang in Java.

The explosion of Krakatoa not only changed very much the conformation of that island, reducing its land area by over two-thirds, but gave rise to immense sea waves, which washed all the surrounding coasts, carrying death and destruction to all in their way, and were still sensibly felt at far distant places in Africa and America. It also caused an atmospheric wave which was traced three times around the earth by irregularities in the tracings of self-registering barometers.

Dr. Fuchs does not favor the idea that the wonderful sky-glows observed during the past winter were caused by dust from Krakatoa disseminated in the upper strata of the atmosphere. And he remarks that "the eruption of Krakatoa although very violent has been equaled or exceeded by others; e. g., that of Asama-yama 1783, of Temboro 1815, of Coseguina 1835, as well as by Hekla 1845, Mauna Loa 1866, and Pochutla 1870. In no one of these cases," he says, "was a similar sky-glow observed." It may be remarked, however, that the absence of any such observation in connection with former great eruptions is by no means conclusive; for some eruptions, as that of Mauna Loa referred to, consisted mostly of lava flows, with which no great amount of ashes was ejected, nor to any great altitude;—others, as Hekla, which exhibited more of the explosive character, were in much higher latitudes and out of the great equatorial currents of the atmosphere; while in earlier cases, as Temboro, the phenomena might easily have escaped recognition and record.

The record of earthquakes includes 263 items, of which 79 are on the American Continent and have been already noticed in this Journal.* By seasons they are distributed as follows:—Winter 56 (Dec. 21, Jan. 21, Feb. 14); Spring 66 (March 22, April 20, May 24); Summer 68 (June 20, July 29, Aug. 19); Autumn 73 (Sept. 29, Oct. 30, Nov. 14). On 41 days there were shocks in two or more localities, and at 24 places there were shocks on several dates.

The most important earthquake was that in Ischia, July 28.† In regard to its causes Dr. Fuchs says:—The earthquake of July, 1883, does not belong to the volcanic earthquakes hitherto frequent in the island; and a real downfall or a collapse of a great cavity finds as little reason. The materials of the hill have only shifted somewhat and rearranged themselves until they again found sufficient support. And this change was completed at a moderate depth. On this account was the surface action of the earthquake uncommonly strong and its extent very limited."

An appendix adds a few items for 1880 and 1882, and notices the monograph of Professor A. Forster on the Berne Earthquake of Jan. 27, 1881; and that of Dr. R. Canaval on the Carinthian Earthquake of Nov. 5, 1881. C. G. R.

3. *Second Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution*, 1880-81; by J. W. POWELL, Director. 477 pp. 4to, with numerous plates and figures. Washington, 1884.—This volume is a worthy companion in its subject matter and illustrations to its predecessor issued a year or so ago. It shows the rapid progress which is being made in the work of studying and recording the languages, manners and customs of our Indian tribes—a work the value and importance of which can hardly be overestimated. The volume

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* vol. xxvii, p. 358.

† vol. xxvi, p. 473.

opens with the report of the Director, in which is given a statement of the plan on which the work is being carried forward, and a summary of the work done by a number of specialists in different subjects. The following is a list of the papers printed in full and making up the bulk of the volume: Zuñi fetiches, by F. H. Cushing; Myths of the Iroquois, by Mrs. Erminnie A. Smith; Animal Carvings from the mounds of the Mississippi Valley, by H. W. Henshaw; Navajo Silversmiths, by Dr. Washington Matthews, U. S. A.; Art in Shell of the ancient Americans, by W. H. Holmes; Illustrated Catalogue of the collections obtained from the Indians of New Mexico and Arizona, in 1879, and from the Indians of New Mexico, in 1880, by James Stevenson. These papers contain a vast amount of interesting and valuable material rendered the more attractive by the profusion of illustrations, upwards of 700 in number, and many of them colored, the excellence of the execution of which leaves nothing to be desired.

4. ***Bulletin of the New England Meteorological Society***, No. 1, November, 1884, with a map.—This bulletin contains a summary of the meteorological conditions of New England for November, based upon reports from forty-five observers, six of whom were connected with the U. S. Signal Service. Besides the statement of the conditions as to precipitation, temperature, storms, wind, auroras and earthquakes, etc., some experiments are mentioned as having been made by Mr. Desmond Fitz Gerald, of Brookline, "to show the highest and lowest temperatures in the open air and in the woods under deciduous, and under pine trees. Extreme differences of 7° in the maximum, and 9° in the minimum temperatures were noted. The mean of twenty-four observations gave the following results:

	Open Air.	Deciduous Woods.	Pine Woods.
Maximum................	50°·62	50°·18	47°·88
Minimum................	25°·82	26°·32	25°·58"

In regard to the objects aimed at by the Society we quote from the Bulletin. "The New England Meteorological Society was formed in Boston, in June, 1884, to promote the study of atmospheric phenomena in New England. The aim of the Society is to promote uniformity and accuracy among observers, to establish systematic observations in new localities, and to discuss and publish the results obtained. . . . The Council has begun its work by undertaking to collect statistics of meteorological phenomena, and to issue a monthly bulletin containing a summary of the observations, with such other items of interest as it may be possible to present from time to time. Special attention is paid to precipitation and range of temperature, and many more observers are needed. Observations are welcomed from any one, whether a member of the Society or not. In order to secure greater uniformity and accuracy in the records, circulars have been prepared containing suggestions as to instruments to be used and the best methods of exposure; they can be obtained on application to the Director, together with blank forms for recording the observations. The Society is a voluntary association, and depends upon the fees of its members for the cost of issuing its bulletin, and for its other expenses. It is, therefore, hoped that all interested in meteorology will connect themselves with it and aid in promoting the objects it has in view. Correspondence relating to the Society and to membership should be addressed to W. M. Davis, Secretary, Cambridge, Mass. Correspondence relating to matters of observation should be addressed to Winslow Upton, Director, Providence, R. I."

5. *American Society for Psychical Research.* — A Society has been recently organized at Boston, the object of which, like that of a similar Society formed in England in 1882, is (to quote from the proceedings of the latter) to make "an organized and systematic attempt to investigate that large group of debatable phenomena designated by such terms as mesmeric, psychical and spiritualistic. From the recorded testimony of many competent witnesses, past and present, including observations recently made by scientific men of eminence in various countries, there appears to be, amidst much illusion and deception, an important body of remarkable phenomena, which are *primâ facie* inexplicable on any generally recognized hypothesis, and which, if incontestably established, would be of the highest possible value. The task of examining such residual phenomena has often been undertaken by individual effort, but never hitherto by a scientific society organized on a sufficiently broad basis. The aim of the Society is to approach these various problems without prejudice or prepossession of any kind, and in the same spirit of exact and unimpassioned inquiry which has enabled science to solve so many problems, once not less obscure nor less hotly debated."

The Committee appointed consists of nine gentlemen, viz: G. Stanley Hall (Chairman), E. C. Pickering, William James, Alpheus Hyatt, Samuel H. Scudder, H. P. Bowditch, C. S. Minot, William Watson, N. D. C. Hodges (Secretary, 19 Brattle street, Cambridge).

6. *American Pearls.* — At the Philadelphia meeting of the American Association for the Advancement of Science, Mr. Geo. F. Kunz read a preliminary paper on the "American Pearl," treating of its history, production, value and uses. Mr. Kunz states that he is still engaged on this subject, which will in the near future be illustrated and published by the United States Fisheries Commission in their bulletin, and he would greatly appreciate, and give full credit for, any reliable facts that may be furnished to him. His address is Tiffany & Co., New York City.

7. *Spaziergänge durch das Reich der Sterne;* Astronomische Feuilletons von M. WILHELM MEYER. 321 pp. 8vo. Vienna, 1885 (A. Hartleben's Verlag).—The author, formerly first astronomer in Geneva, has brought together in this volume a very readable and, for the general public, instructive series of essays upon various astronomical subjects. They are written in a bright fresh style with a good deal of quiet humor. A fair impression

of the character of the volume may be obtained from the titles of some of the chapters taken at random, such as:—The Son of the Earth (the Moon); A well known guest (the Comet Pons); The Star of the three Kings (new Stars); How one becomes an Astronomer (Bessel).

8. *Elisha Mitchell Scientific Society of Raleigh, N. C., Journal for the year* 1883–84.—This society, now a year old, is named after an able professor of Chemistry of the University of North Carolina, Elisha Mitchell—"a naturalist by inheritance, by inclination, by education and by profession"—whose lamented death occurred in 1857, by a fall from a precipice while descending Black Mountain. In 1835 he measured the altitude of this peak, and found it 5,508 feet above Morgantown, which, with the now known height of Morgantown, makes it 6,708 feet above the sea—only 7 feet above the height obtained by Professor Guyot in 1856. His ascent in 1857 was undertaken to remove a lingering doubt as to whether the peak measured was the highest or not of the group. The name given the society is one of many honors to his memory from the citizens of North Carolina. This first publication of the Society contains papers on the phosphatic deposits of North Carolina, by C. W. Dabney, Jr. and W. B. Phillips, analyses of the cassiterite of King's Mountain, N. C., by C. W. Dabney; on Indian Burial Grounds of North Carolina, by J. A. Holmes, and other papers of interest.

9. *Leisure Hours among the Gems;* by AUGUSTUS C. HAMLIN. 439 pp. 8vo, with two colored plates. Boston, 1884 (James Osgood & Co.)—The author has brought together in this volume many interesting facts in regard to the more important gems, their occurrence, history, etc. The scientific theories advanced, however, will not always bear examination, and a good deal of space is given to the discussion of irrelevant matter.

A Treatise on the Principles of Chemistry, by M. M. Pattison Muir, M.A., F.R.S.E. 488 pp. 8vo. Cambridge, 1884. (University Press.)

The Elements of Chemistry, Inorganic and Organic, by Professor Sidney A. Norton. 504 pp. 8vo. Cincinnati and New York, 1884. (Van Antwerp Bragg & Co.)

Bulletin de la Société Belge d'Électriciens, Tome premier, 1884. Brussells.

Bulletin No. 2, of the Illinois State Museum of Natural History, Springfield, Illinois, 28 pp. 8vo. Contains descriptions of new Carboniferous Crustaceans, Mollusks and Crinoids, by A. H. Worthen.

Memoirs of the Geological Survey of India.—Fossil Echinoidea from Western Sind, with 16 plates, by P. Martin Duncan and W. Percy Sladen. Calcutta, 1882

OBITUARY.

HERMANN KOLBE.—It is announced that the German chemist, Professor Hermann Kolbe, died suddenly on the 25th of last November, in his 67th year. A sketch of his life and work is promised to appear in the coming number of the *Journal für praktische Chemie*, of which he was long the editor.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

BENJAMIN SILLIMAN.

Benjamin Silliman, son of Benjamin Silliman the founder of this Journal, and long one of its editors, died at New Haven, Connecticut, on the fourteenth of January, 1885.

Mr. Silliman was born in New Haven, on the fourth of December, 1816. His mother, Harriet Trumbull, was the daughter of Jonathan Trumbull, Governor of the State of Connecticut from 1798 to 1809. Surrounded from his childhood by an atmosphere of science, he early made acquisitions in chemistry and mineralogy, and exhibited also much interest in the practical arts and mechanics. He entered Yale College in August, 1833, and was graduated four years later, with the class of 1837, a class which included an unusual number of men who have since had prominent positions in the country. Before graduation, in the summer of 1836, he began his mining explorations in a visit with his father to the gold region of Virginia, a report on which, over thirty pages in length, by his father, is contained in volume xxxii of this Journal.

After leaving college, in 1837, he became his father's assistant in chemistry and his other departments, a position just then left vacant by the resignation of Mr. J. D. Dana, who had received an appointment to the department of Geology and Mineralogy in the Wilkes Exploring Expedition.

The Laboratory gave him opportunities for experiment and study of which he assiduously availed himself; and by the year 1842 he had, without outside help, of which the country afforded then almost nothing, acquired sufficient knowledge of general and analytical chemistry and mineralogy to enable him to instruct others on these subjects, and he received a few students in what would now be called very narrow quarters in the old laboratory of the college. One of the earliest of these private pupils was Mr. John P. Norton, afterward Mr. Silliman's associate, who studied with him in 1842 and 1843, and later spent two years in laboratories in Edinburgh and Utrecht. Another was Mr. T. Sterry Hunt, who commenced his studies with Mr. Silliman in 1845,—then a young man of 20 years, having some knowledge of chemistry and a zeal for science, which he brought with him from his home in Norwich (Connecticut), that commended him strongly to both the Sillimans.

This was the commencement of work in advanced chemistry in the College; but it was outside of the College curriculum and had no recognition from the College authorities. In 1846 a memoir to the Corporation by himself, adopted and seconded by his father, urging the official recognition and organization of a new department of advanced science, led to the establishment of the "Department of Philosophy and the Arts." The "School of Applied Chemistry" was organized under this department, and placed in the charge of Mr. Silliman, as Professor of Chemistry applied to the Arts, and Mr. John P. Norton, as Professor of Agricultural Chemistry. The school took possession of the old Presidential residence on the college ground, which the professors, without salaries from the college, and at their own expense, fitted up for the purpose—by the permission of College authorities, but without the privilege of using the building free of rent. Thus Mr. Silliman, through his zeal and energy, early made a strong impression on the system of education at Yale; and the College had, almost unknowingly to itself, taken an important step toward the rank and character of a university.

The School was successful from the beginning, and the enthusiasm of the professors called out equal enthusiasm in the pupils. It was the germ from which proceeded later, under an enlarged faculty—though still an unpaid self-sacrificing faculty—the Yale Scientific School; and this prepared the way for the greater expansion under the generous gifts of Mr. Sheffield. Among the six students of the year 1847, the first after the new organization, were three, G. J. Brush, S. W. Johnson and Wm. H. Brewer, who later became professors in the Yale Scientific School, and are still in active service. Mr. Silliman's connection with the Scientific School continued until 1869, but his instruction was interrupted by his residence in Louisville mentioned below, and to a greater or less degree after his return to New Haven by duties in other directions.

In 1838, Mr. Silliman became associated with his father in the editorship of the American Journal of Science and Arts, the Journal then in its 21st year and Mr. Silliman in his 22nd. This arrangement continued until the close of 1845, when the first series of fifty volumes was ended, after which Mr. James D. Dana was associated with Mr. Silliman in the editorial duties. Up to the present time, 1885, his name has stood among those of the editors of the Journal now for nearly half a century.

In the winter of 1845-46, Mr. Silliman gave a course of lectures on Agricultural Chemistry in New Orleans upon the invitation of leading commercial and professional men in that city. In 1849 he received the appointment of Professor of

Medical Chemistry and Toxicology in the Medical College at Louisville, Kentucky, which chair he occupied for five years. Louisville became for the time his place of residence. He relinquished this position in 1854 to enter upon instruction in the Academic and Medical departments of Yale College, his father's resignation having left the place vacant. His position as Professor in General and Applied Chemistry in the Academic College he resigned in 1870, but retained his connection with the Medical School until his death.

In 1851 Mr. Silliman accompanied his father on the latter's second visit to Europe. During the time abroad the party visited England and from there traveled through France to Italy and Sicily. On the return some time was spent in Switzerland and Germany. The journey was a profitable one in many ways. The former European tour of his father, in 1805–6, had been cut short by war which compelled a speedy retreat after a brief time in Holland, and it was a special delight to him now to visit regions of volcanoes and glaciers, which had been subjects of eloquent lectures by him for so many years, and to see face to face the men whose names he had so often quoted, and so long honored—Lyell and Murchison in England, Brongniart, Milne-Edwards and Élie de Beaumont in Paris, Marignac and De la Rive in Geneva, Humboldt, Rose, Liebig and others in Germany; and in this pleasure his son shared most profoundly.

In 1853 Mr. Silliman had charge of the Chemical, Mineralogical and Geological department of the Crystal Palace in New York. At this time he edited, in connection with Mr. Charles R. Goodrich, a large illustrated quarto volume entitled the "World of Science, Art and Industry;" and, in 1854, another similar volume entitled "The Progress of Science and Mechanism."

In March, 1864, he made his first visit to California, where, for about a year, he was engaged in the professional work of examining and reporting on mines. His mining explorations at this time were extended into Arizona; and one of the volumes of this Journal for 1866, contains an account by him of his trip to the Mojave desert, Fort Mojave and the San Francisco Mining district. This visit covered the period of his father's death at New Haven which occurred in November of that year. A second visit to the Pacific States, for a similar purpose, was made by him in the year 1867, and still another in 1872; and after 1872, his journeyings as a mining expert carried him over nearly all the rest of the Rocky Mountain region within the limits of the United States.

Mr. Silliman's scientific publications are numerous and cover a wide field. In 1846, his father's work on chemistry having been long out of print, he published his "First Principles of Chemistry." The work had many excellent features, was highly valued in the country and met with great success, more than fifty thousand copies of the three editions (1846–1858) having been sold. In the part of the work on Organic Chemistry he had the assistance of Dr. T. Sterry Hunt. About ten years later, in 1858, appeared another work, of somewhat similar nature, entitled the "First Principles of Physics or Natural Philosophy;" a second edition of it was published in 1860. For the work the author modestly claimed, in his Preface, only the credit that "belongs to a faithful digest and compilation from the best authorities in modern science." The volume contained a vast amount of matter, well arranged for instruction, and for many years it was the best known of Physical textbooks in the country.

Mr. Silliman's papers in this Journal are more than fifty in number, and embrace a wide range of subjects. The larger part are descriptions of minerals, more especially from the chemical side, and among the papers are many of prominent interest: on the composition of Calcareous Corals (1846); on the new species, Emerald Nickel, from Texas, Pa. (1847); the results of the optical examination of the Micas (1850); on Gay-Lussite from near Ragtown, Nevada (1866), in which the occurrence of this mineral in process of formation is described; on Priceite a new borate of lime (1873); on Platinum and Iridosmine at the Cherokee Gold Mine, California (1873); Tellurium ores of Colorado (1874); on the occurrence of Gold with scheelite in Idaho (1877); on Jarosite in Arizona (1879); on Vanadates, Chromates and Tungstates in Arizona (1881); on the Iron Mountain of Durango, Mexico (1882).

In the department of mineralogy he always took an active interest. His opportunities for collection were large and he accumulated a fine cabinet which, in 1868, was sold to Cornell University, where it bears the name of the Silliman Cabinet. The mineralogical collections of Yale College are indebted to him for various gifts; and through his personal solicitation of funds the Baron Lederer Collection was secured, in 1843, for the college.

Other papers by him relate to meteoric stones and irons, as those of Burlington, N. Y., Lockport, N. Y., of Texas, of Concord, N. H., Shingle Springs, Cal.; points in geology and physical optics; photographic experiments with the voltaic arc, then a matter of novelty; the illuminating powers of gas, etc.

Professor Silliman delivered one of the addresses on the occasion of the celebration of the Centennial of Chemistry at Northumberland, Pennsylvania in August, 1874, which took the form of a full list of American Contributions to Chemistry up to the date of the meeting; it extended to one hundred and seventy-six pages and is a valuable historical work, the result of a vast amount of labor. It contains a complete list of his own papers up to the time of publication.

Mr. Silliman, throughout his life, but especially in the last twenty years, gave a large part of his energies to work in applied science, including the examination of mines, the preparation of reports on questions connected with the chemical arts and manufactures, in which subjects his knowledge was remarkably extensive, expert testimony in courts, and other matters of practical interest. His reports on these subjects have been very numerous and involved a great amount of work. One of the latest and most important, was the report to the National Academy of Sciences, as chairman of a committee appointed by them, on the subject of the use of Sorghum as a source of sugar. His position as State Chemist, to which he was appointed in 1869, also gave him much to do in the line of applied chemistry.

Professor Silliman took a personal interest in the municipal affairs of the town of New Haven, and in his early life, between 1845 and 1849, he was a member of the Common Council. He was one of the fifty original members of the National Academy of Sciences, incorporated by Congress in 1863. He was also a member of a number of other Scientific Societies at home and abroad.

Professor Silliman was a man of exceedingly generous nature and kindly disposition. He was ever cheerful, ever inclined to look upon the bright side of life, hopeful and sanguine of success where others might be discouraged; and if his expectations for himself and others were not always realized, it was largely owing to this element in his character. In society he was most genial, abounding in conversation based on a remarkable range of information on general topics and with anecdote ready for the entertainment of his guests. Hospitality to friends of the College or to men of science or to those of his own kin and personal intimacy was his delight, and to this some of those present at the recent meeting of the British Association can testify.

During the greater part of his life Mr. Silliman enjoyed excellent health. He had much more than the ordinary amount of vigor, and rarely felt the necessity of considering whether he were able to undertake any labor proposed to him or not. Four years since, after an excursion, late in the autumn of 1880 among the mountains of Pennsylvania, he was prostrated for some weeks with heart disease; and it seemed to his friends for awhile that at the best his days of active work were at an end. But in the course of another six months he was off to New Mexico on a visit to the Negretta Mountains (Black Range) in Socorro County; and he returned from the elevated mountain region apparently uninjured by the trip, though conscious of a weakened constitution. His energy was far from giving out; and other excursions were undertaken in the course of the following years, including another trip to New Mexico. His recent illness commenced in October last, with a severe return of his heart complaint, complicated by an attack of pneumonia; and from that time his decline made slow but steady progress—more visible to friends than to himself.

One of the last literary labors which he performed was the preparation, for the National Academy of Sciences, of a memoir of his old friend and colleague at Louisville, Dr. J. Lawrence Smith; and during the last few weeks of his life, when his strength was already largely gone he gave directions, with a touching degree of affection and interest, for the completion of the medal which was to commemorate the labors of his Academic associate. The generous, whole-souled affection for his friends, which characterized his entire life, was never more strongly manifested than during his last days.

The funeral services took place at the College Chapel on the seventeenth of January.

Professor Silliman was married in May, 1840, to Miss Susan H. Forbes of New Haven, eldest child of William J. and Charlotte Root Forbes. Mrs. Silliman died in March, 1878. Four daughters and an only son survive them.

Art. XVI.—*The Organization and Plan of the United States Geological Survey;* by J. W. Powell. With a map (Plate 1). (Communicated to the National Academy of Sciences at the October meeting in 1884.)

A scientific institution or bureau operating under government authority can be controlled by statute and by superior administrative authority but to a limited extent. These operations are practically carried on by specialists, and they can be controlled only in their financial operations and in the general purposes for which investigations are made. Their methods of investigation are their own,—originate with themselves, and are carried out by themselves. But in relation to the scientific operations of such a government institution, there is an unofficial authority which, though not immediately felt, ultimately steps in to approve or condemn, viz: the body of scientific men of the country; and though their authority is not exercised antecedently and at every stage of the work, yet it is so potent that no national scientific institution can grow and prosper without their approval, but must sooner or later fall and perish unless sustained by their strong influence.

As director of the Geological Survey, I deeply realize that I owe allegiance to the scientific men of the country, and for this reason I desire to present to the National Academy of Sciences the organization and plan of operations of the Survey.

A Topographic Map of the United States.

Sound geologic research is based on geography. Without a good topographic map geology cannot even be thoroughly studied, and the publication of the results of geologic investigation is very imperfect without a good map; but with a good map thorough investigation and simple, intelligible publication become possible. Impelled by these considerations the Survey is making a topographic map of the United States. The geographic basis of this map is a trigonometric survey by which datum points are established throughout the country; that is, base-lines are measured and a triangulation extended therefrom. This trigonometric work is executed on a scale only sufficiently refined for map-making purposes, and will not be directly useful for geodetic purposes in determining the figure of the earth. The hypsometric work is based upon the railroad levels of the country. Throughout the greater part of the country, there is a system of railroad lines, constituting a net-work. The levels or profiles of these roads have been established with reasonable accuracy, and as they cross each other at a multiplicity of points, a system of checks is afforded, so that the railroad surface of the country can be determined therefrom with all the accuracy necessary for the most refined and elaborate topographic maps. From such a hypsometric basis the reliefs for the whole country are determined, by running lines of levels, by trigonometric construction, and in mountainous regions by barometric observation.

The primary triangulation having been made, the topography is executed by a variety of methods, adapted to the peculiar conditions found in various portions of the country. To a large extent the plane-table is used. In the hands of the topographers of the Geological Survey the plane-table is not simply a portable drafting table for the field; it is practically an instrument of triangulation, and all minor positions of the details of topography are determined through its use by trigonometric construction.

The scale on which the map is made is variable. In some portions of the prairie region, and in the region of the great plains, the topography and the geology alike are simple, and maps on a comparatively small scale are sufficient for practical purposes. For these districts it is proposed to construct the sheets of the map on a scale of 1-250000, or about four miles to the inch. In the mountain regions of the West the geology is more complex, and the topography more intricate; but to a large extent these regions are uninhabited, and to a more limited extent uninhabitable. It would therefore not be wise to make a topographic or geologic survey of the country on an excessively elaborate plan. Over much of this area the sheets of the map will also be constructed on a scale of 1-250000, but in special districts that scale will be increased to 1-125000, and in the case of important mining districts charts will be constructed on a much larger scale. In the eastern portion of the United States two scales are adopted. In the less densely populated country a scale of 1-125000 is used; in the more densely populated regions a scale of 1-62500 is adopted, or about one mile to the inch. But throughout the country a few special districts of great importance, because of complex geologic structure, dense population, or other condition, will require charts on still larger scales. The area of the United States, exclusive of Alaska, is about three million square miles, and a map of the United States, constructed on the plan set fourth above, will require not less than 2600 sheets. It may ultimately prove to require more than that, from the fact that the areas to be surveyed on the larger scale have not been fully determined. Besides the number of sheets in the general map of the United States, there will be several hundred special maps on large scales, as above described.

Such is a brief outline of the plan so far as it has been developed at the present time. In this connection it should be stated that the map of the United States can be completed, with the present organization of the Geological Survey, in about 24 years; but it is greatly to be desired that the time for its completion may be materially diminished by increasing the topographic force of the Geological Survey. We ought to have a good topographic map of the United States by the year 1900. About one-fifth of the whole area of the United States, exclusive of Alaska, has been completed on the above plan. This includes all geographic work done in the United States under the auspices of the General Government and under the auspices of State governments. The map herewith shows those areas that have been surveyed by various organizations on such a scale and in such a manner that the work has been accepted as sufficient for the purposes of the Survey.

Much other work has been done, but not with sufficient refinement and accuracy to be of present value, though such work subserved its purpose in its time. An examination of the map will show that the triangulation of the various organizations is already largely in advance of the topography. The map of the United States will be a great atlas divided into sheets as above indicated. In all of those areas where the survey is on a scale of 1-250000, a page of the atlas will present an area of one degree in longitude and one degree in latitude. Where the scale is 1-125000, a page of the atlas-sheet will represent one-fourth of a degree. Where the scale is 1-62500, the atlas-sheet will represent one-sixteenth of a degree. The degree sheet will be designated by two numbers—one representing latitude, the other longitude. Where the sheets represent fractional degrees, they will be labeled with the same numbers, with the addition of the description of the proper fractional part.

The organization, as at present established, executing this work, is as follows: First, An astronomic and computing division, the officers of which are engaged in determining the geographic coördinates of certain primary points. Second, A triangulation corps engaged in extending a system of triangulation over various portions of the country from measured base-lines. Third, A topographic corps, organized into twenty-seven parties, scattered over various portions of the United States. Such, in brief outline, is the plan for the map of the United States, and the organization by which it is to be made. Mr. Henry Gannett is the Chief Geographer.

PALEONTOLOGY.

Before giving the outline of the plan for the general geologic survey, it will be better to explain the accessory plans and organizations. There are in the Survey, as at present organized, the following paleontologic laboratories:

1. A laboratory of vertebrate paleontology for formations other than the Quaternary. In connection with this laboratory there is a corps of paleontologists. Professor O. C. Marsh is in charge.
2. There is a laboratory of invertebrate paleontology of Quaternary age, with a corps of paleontologists, Mr. Wm. H. Dall, being in charge.
3. There is a laboratory of invertebrate paleontology of Cenozoic and Mesozoic age, with a corps of paleontologists. Dr. C. A. White is in charge.
4. There is a laboratory of invertebrate paleontology of Paleozoic age, with a corps of paleontologists. Mr. C. D. Walcott is in charge.
5. There is a laboratory of fossil botany, with a corps of paleobotanists, Mr. Lester F. Ward being in charge.

The paleontologists and paleobotanists connected with the laboratories above described, study and discuss in reports the fossils collected by the general geologists in the field. They also supplement the work of the field geologists by making special collections in important districts and at critical horizons; but the paleontologists are not held responsible for areal and structural geology on the one hand, and the geologists are not held responsible for paleontology on the other hand. In addition to the large number of paleontologists on the regular work of the Geological Survey, as above described, several paleontologists are engaged from time to time to make special studies.

CHEMISTRY.

There is a chemic laboratory attached to the Survey, with a large corps of chemists engaged in a great variety of researches relating to the constitution of waters, minerals, ores and rocks. A part of the work of this corps is to study the methods of metamorphism and the paragenesis of minerals, and in this connection the chemists do work in the field; but to a large extent they are occupied with the study of the materials collected by the field geologists. Professor F. W. Clarke is in charge of this department.

PHYSICAL RESEARCHES.

There is a physical laboratory in the Survey, with a small corps of men engaged in certain physical researches of prime importance to geologic philosophy. These researches are experimental, and relate to the effect of temperatures, pressures, etc., on rocks. This laboratory is under the charge of the Chief Chemist.

LITHOLOGY.

There is a lithologic laboratory in the Survey, with a large corps of lithologists engaged in the microscopic study of rocks. These lithologists are field geologists, who examine the collections made by themselves.

STATISTICS.

There is in the Survey a division of mining statistics, with a large corps of men engaged in statistic work, the results of which are published in an annual report entitled "Mineral Resources." Mr. Albert Williams, Jr., is the Chief Statistician of the Survey.

ILLUSTRATIONS.

There is in the Survey a division organized for the purpose of preparing illustrations for paleontologic and geologic reports. Mr. W. H. Holmes is in charge of this division. Illustrations will not hereafter be used for embellishment, but will be strictly confined to the illustration of the text and the presentation of such facts as can be best exhibited by figures and diagrams. All illustrations will, as far as possible, be produced by relief methods, such as wood-engraving, photo-engraving, etc. As large numbers of the reports of the Survey are published, this plan is demanded for economic reasons; but there is another consideration believed to be of still greater importance: illustrations made on stone cannot be used after the first edition, as they deteriorate somewhat by time, and it is customary to use the same lithographic stone for various purposes from time to time. The illustrations made for the reports of the Survey, if on relief-plates that can be cheaply electrotyped, can be used again when needed. This is especially desirable in paleontology, where previously published figures can be introduced for comparative purposes. There are two methods of studying the extinct life of the globe. Fossils are indices of geological formations, and must be grouped by formations to subserve the purpose of geologists. Fossils also have their biologic relations, and should be studied and arranged in biologic groups. Under the plan adopted by the Survey, the illustrations can be used over and over again for such purposes when needed, as reproduction can be made at the small cost of electrotyping. These same illustrations can be used by the public at large in scientific periodicals, text-books, etc. All the illustrations made by the Geological Survey are held for the public to be used in this manner.

LIBRARY.

The library of the Survey now contains more than 25,000 volumes, and is rapidly growing by means of exchanges. It is found necessary to purchase but few books. The librarian, Mr. C. C. Darwin, has a corps of assistants engaged in bibliographic work. It is proposed to prepare a catalogue of American and foreign publications upon American geology, which is to be a general authors' catalogue. In addition to this, it is proposed to publish bibliographies proper of special subjects constituting integral parts of the science of geology.

PUBLICATIONS.

The publications of the Survey are in three series: Annual Reports, Bulletins and Monographs. The Annual Report constitutes a part of the Report of the Secretary of the Interior for each year, but is a distinct volume. This contains a brief summary of the purposes, plans and operations of the Survey, prepared by the Director, and short administrative reports from the chiefs of divisions, the whole followed by scientific papers. These papers are selected as being those of most general interest, the object being to make the Annual Report a somewhat popular account of the doings of the Survey, that it may be widely read by the intelligent people of the country. Of this 5650 copies are published as a part of the Secretary's report, and are distributed by the Secretary of the Interior, Senators and Members of the House of Representatives; and an extra edition is annually ordered of 15,000 copies, distributed by the Survey and members of the Senate and House of Representatives. Four Annual Reports have been published; the Fifth is now in the hands of the printer.

The Bulletins of the Survey are short papers; and through them somewhat speedy publication is attained. Each Bulletin is devoted to some specific topic, in order that the material ultitimately published in the Bulletins can be classified in any manner desired by scientific men. Nine Bulletins have been published, and seven are in press. The Bulletins already published vary in size from 5 to 325 pages each; they are sold at the cost of press-work and paper, and vary in price from five to twenty cents each. 4900 copies of each Bulletin are published; 1900 are distributed by Congress, 3000 are held for sale and exchange by the Geological Survey.

The Monographs of the Survey are quarto volumes. By this method of publication the more important and elaborate papers are given to the public. Six Monographs, with two atlases, have been issued; five Monographs, with two atlases, are in press. 1900 copies of each Monograph are distributed by Congress; 3000 are held for sale and exchange by the Survey at the cost of press-work, paper and binding. They vary in price from $1.05 to $11.

The chiefs of divisions supervise the publications that originate in their several corps. The general editorial supervision is exercised by the Chief Clerk of the Survey, Mr. James C. Pilling.

GENERAL GEOLOGY.

In organizing the general geologic work, it became necessary, first, to consider what had already been done in various portions of the United States; and for this purpose the compilation of a general geologic map of the United States was begun, together with a Thesaurus of American formations. In addition to this the bibliographic work previously described was initiated, so that the literature relating to American geology should be readily accessible to the workers in the Survey. At this point it became necessary to consider the best methods of apportioning the work; that is, the best methods of dividing the geologic work into parts to be assigned to the different corps of observers. A strictly geographic apportionment was not deemed wise, from the fact that an unscientific division of labor would result, and the same classes of problems would to a large extent be relegated to the several corps operating in field and in the laboratory. It was thought best to divide the work, as far as possible, by subject-matter rather than by territorial areas; yet to some extent the two methods of division will coincide. There are in the survey at present:

First, a division of glacial geology, and Prof. T. C. Chamberlin, formerly State Geologist of Wisconsin, is at its head, with a strong corps of assistants. There is an important field for which definite provision has not yet been made, namely, the study of the loess that constitutes the bluff formations of the Mississippi River and its tributaries. But as this loess proves to be intimately associated with the glacial formations of the same region, it is probable that it will eventually be relegated to the glacial division. Perhaps the division may eventually grow to such an extent that its field of operations will include the whole Quaternary geology.

Second, a division of volcanic geology is organized and Capt. Clarence E. Dutton, of the Ordnance Corps of the Army, is placed in charge, also with a strong corps of assistants.

Third and fourth, two divisions have been organized to prosecute work on the Archæan rocks, embracing within their field not only all rocks of Archæan age, but all metamorphic crystalline schists, of whatever age they may be found. The first division has for its chief, Prof. Raphael Pumpelly, assisted by a corps of geologists, and the field of his work is the crystalline schists of the Appalachian region, or eastern portion of the United States, extending from northern New England to Georgia. He will also include in his studies certain Paleozoic formations which are immediately connected with the crystalline schists and involved in their orographic structure.

The second division for the study of this class of rocks is in charge of Prof. Roland D. Irving, with a corps of geologists, and his field of operation is in the Lake Superior region. It is not proposed at present to undertake the study of the crystalline schists of the Rocky Mountain region.

Fifth, another division has been organized for the study of the areal, structural, and historical geology of the Appalachian region, extending from the Atlantic, westward, to the zone which separates the mountain region from the great valley of the Mississippi. Mr. G. K. Gilbert has charge of this work, and has a large corps of assistants.

Sixth, it seemed desirable, partly for scientific reasons and partly for administrative reasons, that a thorough topographic and geologic survey should be made of the Yellowstone Park, and Mr. Arnold Hague is in charge of the work, with a corps of assistants. When it is completed, his field will be expanded so as to include a large part of the Rocky Mountain region, but the extent of the field is not yet determined.

It will thus be seen that the general geologic work relating to those areas where the terranes are composed of fossiliferous formations is very imperfectly and incompletely organized. The reason for this is two fold: first, the work cannot be performed very successfully until the maps are made; second, the Geological Survey is necessarily diverting much of its force to the construction of maps, and cannot with present appropriations expand the geologic corps so as to extend systematic work in the field over the entire country.

Economic Geology.

Under the organic law of the Geological Survey, investigations in economic geology are restricted to those States and Territories in which there are public lands; the extension of the work into the eastern portion of the United States included only that part relating to general geology. Two mining divisions are organized. One, in charge of Mr. George F. Becker, with headquarters at San Francisco, California, is at the present time engaged in the study of the quicksilver districts of California. The other, under charge of Mr. S. F. Emmons, with headquarters at Denver, Colorado, is engaged in studying various mining districts in that State, including silver, gold, iron and coal areas. Each division has a corps of assistants. The lignite coals of the upper Missouri, also, are under investigation by Mr. Bailey Willis, with a corps of assistants.

EMPLOYÉS.

The employés on the Geological Survey at the close of September, 1884, were as follows:

Appointed by the President, by and with the advice and consent of the Senate (Director), 1.

Appointed by the Secretary of the Interior, on the recommendation of the Director of the Survey, 134.

Employed by the chiefs of parties in the field, 148.

APPOINTMENTS.

Three classes of appointments are made on the Survey. The statute provides that "the scientific employés of the Geological Survey shall be selected by the Director, subject to the approval of the Secretary of the Interior, exclusively for their qualifications as professional experts." The provisions of this statute apply to all those cases where scientific men are employed who have established a reputation, and in asking for their appointment the Director specifically states his reasons, setting forth the work in which the person is to be employed, together with his qualifications, especially enumerating and characterizing his published works. On such recommendations appointments are invariably made. Young men who have not established a reputation in scientific research, are selected through the agency of the Civil Service Commission on special examination, the papers for which are prepared in the Geological Survey. About one-half of the employés, however, are temporary, being engaged for services lasting for a few days or a few months only, largely in the field, and coming under two classes: skilled laborers and common laborers. Such persons are employed by the Director or by the heads of divisions, and are discharged from the service when no longer needed. It will be seen that the Director is responsible for the selection of the employés, directly for those whom he recommends for appointment, and indirectly for those selected by the

Civil Service Commission, as he permanently retains in the work. If, then, improper persons are employed, it is wholly the Director's fault.

The appropriations made for the Geological Survey for the fiscal year ending June 30, 1885, aggregate the sum of $504,040. This sum does not include the amount appropriated for ethnologic researches, $40,000. Nor are the expenses for engraving and printing paid for from the above appropriations, but from appropriations made for the work under the direction of the Public Printer. It is estimated that the amount needed for engraving and printing for the same fiscal year will exceed $200,000.

THE RELATION OF THE GOVERNMENT SURVEY TO STATE SURVEYS.

The United States Geological Survey is on friendly relations with the various State Surveys. Between the Government Survey and the State Survey of New York, there is direct coöperation. The State Survey of Pennsylvania has rendered valuable assistance to the Government Survey, and negotiations have been entered into for closer relations and more thorough coöperation. The State Surveys of North Carolina, Kentucky and Alabama, are also coöperating with the Government Survey, and the Director of the Government Survey is doing all within his power to revive State Surveys. The field for geologic research in the United States is of great magnitude, and the best results can be accomplished only by the labors of many scientific men engaged for a long term of years. For this reason it is believed that surveys should be established in all of the States and Territories. There is work enough for all, and the establishment of local surveys would greatly assist the general work prosecuted under the auspices of the Government, and prevent it from falling into perfunctory channels. Its vigor and health will doubtless be promoted by all thorough local research.

It may be of interest to scientific men to know that the Director finds that in presenting the general results, interests, and needs of the Survey to Congress, and to Committees of Congress, a thorough appreciation of the value of scientific research is shown by the statesmen of the country. Questions relating to immediately economic values are asked, as they should be; but questions relating to sound administration, wise methods of investigation, and important scientific results are vigorously urged, and the principle is recognized that all sound scientific research conduces to the welfare of the people, not only by increasing knowledge, but ultimately by affecting all the industries of the people.

ART. XVII.—*Memorial of George Bentham;* by ASA GRAY.

[From the Report of the Council of the American Academy of Arts and Sciences, for the year 1884–5.)

GEORGE BENTHAM, one of the most distinguished botanists of the present century, and at the time of his death one of the oldest, was born at Stoke, a suburb of Portsmouth, September 22, 1800. He died at his house, No. 25 Wilton Place, London, on the 10th of September, 1884, a few days short of 84 years old. His paternal grandfather, Jeremiah Bentham, a London attorney or solicitor, had two sons, who both became men of mark, Jeremy and Samuel. The latter and younger had two sons, only one of whom, the subject of this memoir, lived to manhood. George Bentham's mother was a daughter of Dr. George Fordyce, a Scottish physician who settled in London, was a Fellow of the Royal Society, a lecturer on chemistry, and the author of some able medical works, also of a treatise upon Agriculture and Vegetation. It was from his mother that George Bentham early imbibed a fondness for botany.

The early part of his life and education was somewhat eventful and peculiar, and in strong contrast with the later. His father, General, subsequently Sir Samuel Bentham, was an adept in naval architecture. At the age of twenty-two he visited the arsenals of the Baltic for the improvement of his knowledge; thence he traveled far into Siberia. He became intimate with Prince Potemkin, by whom he was induced to enter the civil and afterwards the military service of the Empress Catharine. He took part in a naval action against the Turks on the Black Sea, and was rewarded with the command of a regiment stationed in Siberia, with which he traversed the country even to the frontiers of China. After ten years he returned to England, where his inventive skill and experience found a fitting field in the service of the Admiralty, in which he attained the post of Inspector-General of Naval Works. Among the services he rendered was that of bringing to England the distinguished engineer, Isambard Mark Brunel. In the year 1805, Gen. Bentham was sent by the Admiralty to St. Petersburg to superintend the building in Russia of vessels for the British Navy. He took his family with him; and there began the education of George Bentham, in the fifth year of his age, under the charge of a Russian lady who could speak no English, where he learned to converse fluently in Russian, French, and German, besides acquiring the rudiments of Latin as taught by a Russian priest. On the way back to England two or three years later, the detention of a month or two in Sweden gave opportunity for learning enough of Swedish to converse in that language and to read it with tolerable ease in after life. Returning to England the family settled at Hampstead, and the children pursued their studies under private tutors. In the years 1812–13, during the excitement produced by the French invasion of Russia and the burning of Moscow, our young polyglot "budded into an author, by translating (along with his brother and sister) and contributing to a London magazine a series of articles from the Russian newspapers, detailing the operations of the armies." In 1814, upon the downfall of Napoleon, the Bentham family crossed over to France, prepared for a long stay, remained in the country (at Tours, Saumur, and Paris) during the hundred days preceding Napoleon's final overthrow; and in 1816 Sir Samuel Bentham set out upon a prolonged and singular family tour, *en caravane*, through the western and southern departments of France. To quote from the published account from which most of these biographical details are drawn, and which were taken from Mr. Bentham's own memoranda:*

"The *cortége* consisted of a two-horse coach fitted up as a sleeping apartment; a long, low, two-wheeled, one-horse spring van for Gen. and Mrs. Bentham, furnished with a library and piano; and another, also furnished, for his daughters and their governess. The plan followed was to travel by day from one place of interest to another, bivouacking at night by the road, or in the garden of a friend, or in the precincts of the prefectures, to which latter he had credentials from the authorities in the capital. In this way he visited Orleans, Tours, Angoulême, Bordeaux, Toulouse, Montpellier, and finally Montauban, where a lengthened stay was made in a country house hired for the purpose. From Montauban (the *cortége* having broken down in some way) they proceeded still by private conveyances to Carcassone, Narbonnes, Nîmes, Tarascon, Marseilles, Toulon, Hyères."

It was in the early part of this tour that young Bentham's attention was first turned to botany. Happening to take up DeCandolle's edition of Lamarck's *Flore Française*, which his mother, who was fond of the subject, had just purchased, he was struck with the methodical analytical tables, and he proceeded immediately to apply them to the first plant he could lay hold of. "His success led him to pursue the diversion of naming every plant he met with." During his long stay at Montauban he entered as a student in the Protestant theological school of that town, pursuing, "with ardor the courses of mathematics, Hebrew, and comparative philology, the latter a favorite study in after life," and at home giving himself to music, in which he was remarkably gifted, to Spanish, to botany, and, with great relish, to society. Soon after, the family was established upon a property of 2,000 acres, purchased by his father in the vicinity of Montpellier. Here he resumed the intimacy of his boyhood with John Stuart Mill, who was five years his junior, and whose life-long taste for botany was probably fixed during this residence of seven or eight months in the Bentham family in the year 1820. About this time Bentham occupied himself with ornithology and then with entomology, finding time, however, for another line of study; for at the age of twenty he had begun a translation into French of his uncle Jeremy's Chrestomathia, which was published in Paris some years afterwards, and he soon after translated also the essay on Nomenclature and Classification. This was followed by his own *Essai sur la Nomenclature et Classification*, published in Paris. This, his original scientific production, was one of some mark, for it is praised by Stanley-Jevons in his recent History of the Sciences.

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* An article in Nature, October 2, 1884, by Sir Joseph Dawson Hooker.

On attaining his majority, his elder and only brother having died, he was placed in management of his father's Provençal estate, an employment which he took up with alacrity and prosecuted with success, turning to practical account his methodical habits, his indomitable industry, and his familiarity with Provençal country life and language. The latter he spoke like a native. A language always seemed to come to him without effort. Meanwhile his leisure hours were given to philosophical studies, his holidays to botanical excursions into the Cevennes and the Pyrenees. In the year 1823, a visit to England upon business relating to his father's French estate, where it seemed probable that he was to spend his life, was followed by circumstances which gave him back to his native country. He brought to his uncle Jeremy a French translation of the latter's Chrestomathia; he made the acquaintance of Sir James Edward Smith, Robert Brown, Lambert, Don, and the other English botanists of the day; visited Sir William, then Professor Hooker, at Glasgow, and Walker Arnott in Edinburgh; took the latter with him the next summer to France, where the two botanists herborized together in Languedoc and the Pyrenees; and, returning to London, he accepted his uncle's pressing invitation to remain and devote a portion of his time to the preparation of the latter's manuscripts for the press, at the same time pursuing legal studies at Lincoln's Inn. He was in due time called to the bar, and in 1832 he held his first and last brief. In that year Jeremy Bentham died, bequeathing most of his property to his nephew. This was much less than was expected, owing to bad management on his uncle's part and to the extravagant sums spent by his executors in the publication of the philosopher's posthumous works. But it sufficed, in connection with the paternal inheritance, which fell to him the year previous, for the modest independence which allowed of undistracted devotion to his favorite studies. These were for a time divided between botany, jurisprudence, and logic, not to speak of editorial work upon his father's papers relating to the management of the navy and the administration of the national dock yards.

The first publication was botanical, and was published in Paris, in the year 1826, his *Catalogue des Plantes Indigènes des Pyrénées et du Bas Languedoc.* To this is prefixed an interesting narrative of a botanical tour in the Pyrenees, and some remarks upon the mode of preparing such catalogues in order to their greatest utility,—remarks which already evince the wisdom for which he was distinguished in after years. He also reformed and re-elaborated four difficult genera of the district, Cerastium, Orobanche, Helianthemum, and Medicago. The next, perhaps, was an article upon codification—wholly disagreeing with his uncle—which attracted the attention of Brougham, Hume and O'Connell; also one upon the laws affecting larceny, which Sir Robert Peel complimented and made use of, and another on the law of real property.

But his most considerable work of the period received scant attention at the time from those most interested in the subject, and passed from its birth into oblivion, from which only in these later years has it been rescued, yet without word or sign from its author. This work (of 287 octavo pages) was published in London in 1827, under the title of "*Outline of a New System of Logic, with a critical examination of Dr. Whately's Elements of Logic.*" It was in this book that the quantification of the predicate was first systematically applied, in such wise that Stanley-Jevons* declares it to be "undoubtedly the most fruitful discovery made in abstract logical science since the time of Aristotle." Before sixty copies of the book had been sold, the publisher became bankrupt, and the whole impression of this work of a young and unknown author was sold for waste paper. One of the extant copies, however, came into the hands of the distinguished philosopher, Sir William Hamilton, to whom the discovery of the quantification of the predicate was credited, and who, in claiming it, brought "an acrimonious charge of plagiarism" against Professor De Morgan upon this very subject. Yet this very book of Mr. Bentham is one of the ten placed by title at the head of Sir Wm. Hamilton's article on logic in the Edinburgh Review for April, 1833, is once or twice referred to in the article, and, a dozen years later, in the course of the controversy with De Morgan, Sir William alluded to this article as containing the germs of his discovery. We may imagine the avidity with which De Morgan, injuriously attacked, would have seized upon Mr. Bentham's book if he had known of it. It is not so easy to understand how Mr. Bentham—although now absorbed in botanical researches—could have overlooked this controversy in the Athenæum, or how, if he knew of it, he could have kept silence. It was only at the close of the year 1850, that Mr. Warlow sent from the coast of Wales a letter to the Athenæum, in which he refers to Bentham's book as one which had long before anticipated this interesting discovery. Although Hamilton himself never offered explanation of his now unpleasant position (for the note obliquely referring to the matter in the second edition of his Discussions is not an explanation), Mr. Baine did (in the Athenæum for Feb. 1, 1851) immediately endeavor to discredit the importance of Bentham's work, and again in 1873 (Contemporary Review, xxi), in reply to Herbert Spencer's reclamation of Bentham's discovery. To this Stanley-Jevons made reply in the same volume (pp. 821–824); and later, in his Principles of Science (ii. 387), this competent and impartial judge, in speaking of the connection of Bentham's work "with the great discovery of the quantification of the predicate," adds:

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* In Contemporary Review, xxi, 1873, p. 823.

"I must continue to hold that the principle of quantification is explicitly stated by Mr. Bentham; and it must be regarded as a remarkable fact in the history of logic, that Hamilton, while vindicating in 1847, his own claims to originality and priority as against the scheme of De Morgan, should have overlooked the much earlier and more closely related discoveries of Bentham."

It must be that Hamilton reviewed Bentham's book without reading it through, or that its ideas did not at the time leave any conscious impression upon the reviewer's mind, yet may have fructified afterwards.

After his uncle's death in 1822, Mr. Bentham gave his undivided attention to Botany. He became a Fellow of the Linnean society in 1828. Robert Brown soon after presented his name to the Royal Society, but withdrew it before the election, to mark the dissatisfaction on the part of scientific men with the management of the society when a Royal Duke was made president. Consequently he did not become F. R. S. until 1862. In 1829, when the Royal Horticultural Society was much embarrassed, he accepted the position of Honorary Secretary, with his friend Lindley as associate. Under their management it was soon extricated from its perilous condition, attained its highest prosperity and renown, and did its best work for horticulture and botany. In 1833 he married the daughter of Sir Harford Brydges, for many years British

Ambassador in Persia, and the next year he took up his residence in the house in Queen Square Place, Westminster, inherited from his uncle, in which Jeremy Bentham and his own paternal grandfather had dwelt for almost a century. The house no longer exists, but upon its site stands the western wing of the "Queen Anne Mansions." The summer of 1836 was passed in Germany, at points of botanical interest and wherever the principal herbaria are preserved, the whole winter in Vienna. Some account of this tour and interesting memoranda of the botanists, gardens, and herbaria visited, communicated in familiar letters to Sir William Hooker, were printed at the time (without the author's name) in the second volume of the Companion to the Botanical Magazine. Similar visits for botanical investigation, mingled with recreation, were made almost every summer to various parts of the continent; in one of them he revisited the scenes of his early boyhood in Russia, traveled with Mrs. Bentham to the fair at Nischnii-Novgorod, and thence to Odessa, by the rude litter-like conveyances of the country.

In 1842 he removed with his herbarium to Pontrilas House in Herefordshire, an Elizabethan mansion belonging to his brother-in-law, and combined there the life of a country squire with that of a diligent student, until 1854, when, returning to London, he presented his herbarium and botanical library to the Royal Gardens at Kew, where they were added to the still larger collections of Sir William Hooker. After a short interval Mr. Bentham took up his residence at No. 25 Wilton Place, between Belgrave Square and Hyde Park, which was his home for the rest of his life. Thence, autumn holidays excepted, with perfect regularity for five days in the week he resorted to Kew, pursued his botanical investigations from ten to four o'clock, then, returning, he wrote out the notes of his day's work before dinner, hardly ever breaking his fast in the long interval. With such methodical habits, with freedom from professional or administrative functions which consume the precious time of most botanists, with steady devotion to his chosen work, and with nearly all authentic materials and needful appliances at hand or within reach, it is not surprising that he should have undertaken and have so well accomplished such a vast amount of work: and he has the crowning merit and happy fortune of having completed all that he undertook.

Nor did he decline duties of administration and counsel which could rightly be asked of him. The Presidency of the Linnean Society, which he accepted and held for eleven years (1863 to 1874), was no sinecure to him; for he is said to have taken on no small part of the work of Secretary, Treasurer, and Botanical Editor. Somewhat to the surprise of his younger associates, who knew him only as the recluse student, he made proof in age of the fine talent for business and the conduct of affairs which had distinguished his prime in the management of the Horticultural Society; and in his annual presidential addresses, which form a volume of permanent value, his discussions of general as well as of particular scientific questions and interests bring out prominently the breadth and fulness of his knowledge and the soundness of his judgment.

The years which followed his retirement from the chair of the Linnean Society, at the age of seventy-three, were no less laborious or less productive than those preceding; at the age of eighty (as the writer can testify) the diminution of bodily strength had wrought no obvious abatement of mental power and not much of facility; and he was able to finish in the spring of 1883 the great work upon which he was engaged. As was natural his corporeal strength gave way when his work was done. After a year and a half of increasing debility he died simply of old age—the survivor of his wife for three or four years, the last of the Benthams, for he had no children, nor any collateral descendants of the name.

A large part of his modest fortune was bequeathed to the Linnean Society, to the Royal Society, for its scientific relief fund, and in other trusts for the promotion of the science to which his long life was so perseveringly devoted.

The record of no small and no unimportant part of a naturalist's work is to be found in scattered papers, and those of George Bentham are quite too numerous for individual mention. The series begins with an article upon *Labiatæ*, published in the Linnæa in 1831; it closes with one in the Journal of the Linnean Society, read April 19, 1883, indicating the parts taken by the two authors in the elaboration of the Genera Plantarum, then completed. Counting from the date of the Catalogue of Pyrenean plants, 1826, there are fifty-seven years of authorship. His first substantial volume in botany was the *Labiatarum Genera et Species*, or a description of the genera and species of plants of the order *Labiatæ* with their general history, characters, affinities, and geographical distribution, an octavo of almost 800 pages, of which the first part was published in 1832, the last in 1836. He found even the European part of this large order in much confusion; his monograph left its seventeen hundred and more of species so well arranged (under 107 genera and in tribes of his own creation), that there was little to alter, except as to the rank of certain groups, when he revised them for the Prodromus in 1848, and finally revised the genera (now increased to 136, and with estimated species almost doubled) for the Genera Plantarum in 1876. Although the work of a beginner, it took rank as the best extant monograph of its kind, viz: one of a large natural order, without plates. In it Mr. Bentham first set the example, in any large way, of consulting all the available herbaria for the inspection and determination of type-specimens. To this end he made journeys to the continent every year from 1830 to 1834, visiting nearly all the public and larger private herbaria.

In the years during which the monograph of *Labiatæ* was in progress, Mr. Bentham elaborated and published the earlier of the papers which have particularly connected his name with North American Botany. These are, first, the reports on some of the new ornamental plants raised in the Horticultural Society's Garden from seeds collected in Western North America by Douglas, under the auspices of that society, by which were first made known to botanists and florists so many of the characteristic genera and species of Oregon and California, now familiar in gardens, Gilias and Nemophilas, Limnanthes, Phacelias, Brodiæas, Calochorti, Eschscholtzias, Collinsias, and the like; then the monograph of *Hydrophylleæ* (1834), followed the next year by that on *Hosackia*, and that on the *Eriogoneæ*,—all American and chiefly North American plants,—the first fruits of a great harvest which even now has not wholly been gathered in, the field is so vast, though the laborers have not been few. Later the *Plantæ Hartwegianæ*, an octavo volume begun in 1839, but finished in 1857 with the Californian collections; and in 1844, the *Botany of the Voyage of the Sulphur*, in quarto, the first part of which relates to Californian botany. The various papers upon South American Botany are even more numerous; one of them being that in which Heliamphora, of British Guiana, a new genus of Pitcher Plants, of the Sarracenia family, was established.

Bentham's labors upon the great order *Leguminosæ* began early, with his *Commentationes de Leguminosarum Generibus*, published in the Annals of the Vienna Museum, being the work of a winter's holiday (1836–7) passed in that capital, in the herbarium then directed by Endlicher. This was followed by a series of papers, mostly monographs of genera, in Hooker's Journal of Botany, in the Journal of the Linnean Society, and elsewhere, by the elaboration of the order for the imperial Flora Brasiliensis, and later, by the *Revision of the Genus Cassia* and that of the *Sub-order Mimoseæ*, in the Transactions of the Linnean Society, the latter (a quarto volume in size) published as late as the year 1875. Both are perfect models of monographical work.

An important series of monographs in another and more condensed form was contributed to DeCandolle's Prodromus, namely, the Tribe *Ericeæ* in the seventh volume, the *Polemoniaceæ* in the ninth, the *Scrophulariaceæ* in the tenth, the *Labiatæ* forming the greater part of the twelfth, and the *Eriogoneæ* in the fourteenth; these together filling 1133 pages according to the surviving editor. If not quite the largest collaborator of the DeCandolles, as counted in pages, he was so in the number of plants described, and his work was of the best. It was also ready in time, which is more than can be said of the collaborators in general.

There are few parts of the world upon the botany of which Mr. Bentham has not touched—Tropical America, in the ample collections of Mr. Spruce, and those of Hartweg, distributed, and the former partly and the latter wholly determined by him, as also Hinds' collections made in the voyage of the Sulphur, besides what has already been adverted to; Polynesia, from Hinds' and Barclay's collections; Western Tropical Africa, in the Niger Flora, most of the *Flora Nigritiana* being from his hand; the *Flora Hongkongensis*, in which he began the series of British Colonial floras, and finally that vast work, the *Flora Australiensis*, in seven volumes, which the author began when he was over sixty years old and finished when he was seventy-seven. Nor did he neglect the cultivation of the narrow and more exhausted field of British Botany. His *Handbook of the British Flora*, for the use of beginners and amateurs, published in 1858, has gone through four large editions. Its special object was to enable a beginner or a mere amateur, with little or no previous scientific knowledge and without assistance, to work out understandingly the characters by which the plants of a limited flora may be distinguished from each other, these being expressed as much as possible in ordinary language, or in such technical terms as could be fully explained in the book itself and easily apprehended by the learner. The immediate and continued popularity of this handy volume, bringing the light of full knowledge and sound method to guide the beginner's way, illustrates the advantage of having elementary works prepared by a master of the subject, whenever the master will take the necessary pains. To the same end, the author prepared for this volume an excellent and terse introduction to structural and descriptive botany, which has been prefixed to all the Colonial Floras. In the first edition to this British Flora it was attempted to use or to give English names to the genera and species throughout. This could be done only in such a familiar and well-trodden field as Britain, where almost every plant was familiar; but even here it failed, and in later editions the popular names were relegated to a subordinate position.

It has been stated that Mr Bentham was over sixty years old when he undertook the *Flora Australiensis*, and he was seventy-seven when he brought this vast work to completion, assisted only in notes and preliminary studies by Baron von Mueller of Melbourne. About the same time he courageously undertook the still greater task of a new *Genera Plantarum*, to be worked out, not, like that of Endlicher, mainly by the compilation of published characters into a common formula, but by an actual examination of the extant materials, primarily those of the Kew herbaria,– this work, however, in conjunction with his intimate associate, Sir Joseph Hooker. This work is the only "joint production" in which Mr. Bentham ever engaged. The relations and position of the two authors made the association every way satisfactory, and the magnitude of the task made it necessary. The training and the experience of the two associates were very different and in some ways complemental, one having the greatest herbarium knowledge of any living botanist, the other, the widest and keenest observer of vegetable life under "whatever climes the sun's bright circle warms," as well as of Antarctic regions which it warms very little. It would be expected, on the principle "juniores ad labores," that the laboring oar would be taken by the younger of the pair. It was long and severe work for both; but the veteran was happily quite free from, and his companion heavily weighted by, onerous official duties and cares; and so it came to pass that about two-thirds of the orders and genera were elaborated by Mr. Bentham. In April, 1883, the completion of the work (i. e., of the genera of Phænogamous plants, to which it was limited) closed this long and exemplary botanical career; and the short account which he gave to the Linnean Society on the nineteenth of that month, specifying the conduct of the work and the part of the respective authors, was his last publication.

In this connexion, mention should also be made of the essays (which he simply calls "Notes") upon some of the more important orders which he investigated for the Genera Plantarum,—the Compositæ, the Campanulaceous and the Oleaceous orders, the Monocotyledoneæ as to classification, the Euphorbiaceæ, the Orchis family, the Cyperaceæ and the Gramineæ. These are not mere abstracts, issued in advance, but critical dissertations, with occasional discussions of some general or particular question of terminology or morphology. When collected they form a stout volume, which, along with the volume made up of his anniversary addresses when president of the Linnean Society, and the paper on the progress and state of systematic botany, read to the British Association for the Advancement of Science in 1874, should be much considered by those who would form a just idea of the largeness of Mr. Bentham's knowledge and the character of his work.

It will have been seen that Mr. Bentham confined himself to the Phænogamia, to morphological, taxonomical and descriptive work, not paying attention to the Cryptogamia below the Ferns, nor to vegetable anatomy, physiology, or palæontology. He was what will now be called a botanist of the old school. Up to middle age and beyond he used rather to regard himself as an amateur, pursuing botany as an intellectual exercise. "There are diversities of gifts;" perhaps no professional naturalist ever made more of his, certainly no one ever labored more diligently, nor indeed more successfully over so wide a field, within these chosen lines. For extent and variety of good work accomplished, for an intuitive sense of method, for lucidity and accuracy, and for insight, George Bentham may fairly be compared with Linnæus, DeCandolle, and Robert Brown.

His long life was a perfect and precious example, much needed in this age, of persevering and thorough devotion to Science while unconstrained as well as untrammeled by professional duty or necessity. For those endowed with leisure, to "live laborious days" in her service, it is not a common achievement.

The tribute which the American Academy of Sciences pays to the memory of a deceased Foreign Honorary Member might here fittingly conclude. But one who knew him long and well may be allowed to add a word upon the personal characteristics of the subject of this memorial; the more so that he is himself greatly indebted for generous help. For, long ago, when in special need of botanical assistance, Mr. Bentham invited him and his companion to his house at Pontrilas, and devoted the greater part of his time for two months to this service. Mr. Bentham's great reserve and dryness in general intercourse and his avoidance of publicity might give the impression of an unsympathetic nature. But he was indeed most amiable, warm-hearted, and even genial, "the kindest of helpmates," the most disinterested of friends.

ART. XVIII.—*Paleontologic Notes;* by CHARLES D. WALCOTT, *of the U. S. Geological Survey.*

IN reviewing the material from the St. John Group of New Brunswick, contained in the Hartt collection at Cornell University, the following species were found:

Eocystites primævus Billings.
Lingula? Dawsoni Matthew.
Acrothele Matthewi Hartt, sp.
Linnarssonia transversa Hartt, sp.
Obolella?, sp. undet.
Orthis Billingsi Hartt.
Orthis, sp. ?.
Stenotheca Acadica Hartt, sp.
Harttia Matthewi Walcott, n. gen., n. sp.
Hyolithes Acadica Hartt.
H. Danianus Matthew, mss.
H. Micmac Matthew, mss.
Agnostus Acadicus Hartt.
Microdiscus Dawsoni Hartt.
M. punctatus Salter ?.
Paradoxides lamellatus Hartt.
P. Acadicus Matthew.
P. Etiminicus Matthew.
Conocoryphe Matthewi Hartt.
C. elegans Hartt.
C. (Salteria) Baileyi Hartt.
Ptychoparia Robbi Hartt.
P. Ouangondiana Hartt.
P. Ouangondiana, var. *Aurora* Hartt.
P. quadrata Hartt.
P. Orestes Hartt.
P. Orestes, var. *Thersites* Hartt.
P. tener Hartt.

The *Obolella transversa* of Hartt is clearly allied to *O. sagittalis* Salter, and is not a true Obolella, but represents a genus not yet defined.

Mr. Davidson* called attention to the differences between *O. chromatica*, the type of the genus, and *O. sagittalis.* Later Mr. S. W. Ford† compared the two forms, and suggested that *O. sagittalis* probably represented a new genus. When studying the Obolella-like forms from Nevada, I arrived at the same conclusion (1882),‡ and placed the species in three groups, taking *O. gemma* Bill., *O.* (*desquamata*) = *crassa* Hall, as typical of the genus Obolella; *O.? polita* Hall, *O. ambigua* Walcott, as representing the second group, and *O. sagittalis* the third. In studying *O. transversa* Hartt, the similarity between it and *O. sagittalis* was noted. For this type the following genus is proposed in honor of the late Dr. G. Linnarsson.

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* Monogr. Brit. Foss. Brach., p. 338. † This Journal, vol. xxi, p. 133, 1881.
‡ Pal. Eureka District, Mon. viii, U. S. Geol. Survey.

FAMILY OBOLIDÆ.

LINNARSSONIA, n. gen.

Shell calcareous, transversely or longitudinally ovate, subcircular; convex in the typical species; valves inarticulate. Ventral valve convex with the eccentric apex perforated by a minute foramen; no area; cardinal edge thin. Dorsal valve convex in the species thus far known; without any area.

In the interior of the ventral valve two oval and oblique scars lie each side of the slightly raised rim surrounding the minute foraminal opening and close to the posterior margin; from the foraminal rim a groove extends obliquely forward and outward on each side, so as to enclose a projecting ʌ shaped ridge that is highest at its posterior margin, just in front of the circular foraminal opening.

In the interior of the dorsal valve two large, irregularly circular scars are situated close to the posterior margin and separated by a low, flat ridge that extends forward between the two small divaricator scars. Type, *Obolella transversa* Hartt.

Mr. Davidson did not find that the ventral valve of *Obolella sagittalis* was perforated, but if finely preserved specimens of the exterior of the valve can be obtained, I have little doubt but that the apex will be found to be perforated by a minute foramen.

In an almost identical form Mr. Linnarsson* found the ventral valve to be perforated, and also describes a pedicle groove that, as yet, we fail to find in *L. transversa.*

The Obolella-like form figured by Barrande and De Verneuil† has the ventral valve perforate, and appears to be closely related to the genus under consideration.

The plan of the interior of the ventral and dorsal valves of *Obolella chromatica* are given as in Mr. S. W. Ford's paper,‡ and the interiors of *L. transversa* from drawings from the types of the species.

In a future paper I will endeavor to bring together descriptions and illustrations of all the American Cambrian species of *Obolidæ.*

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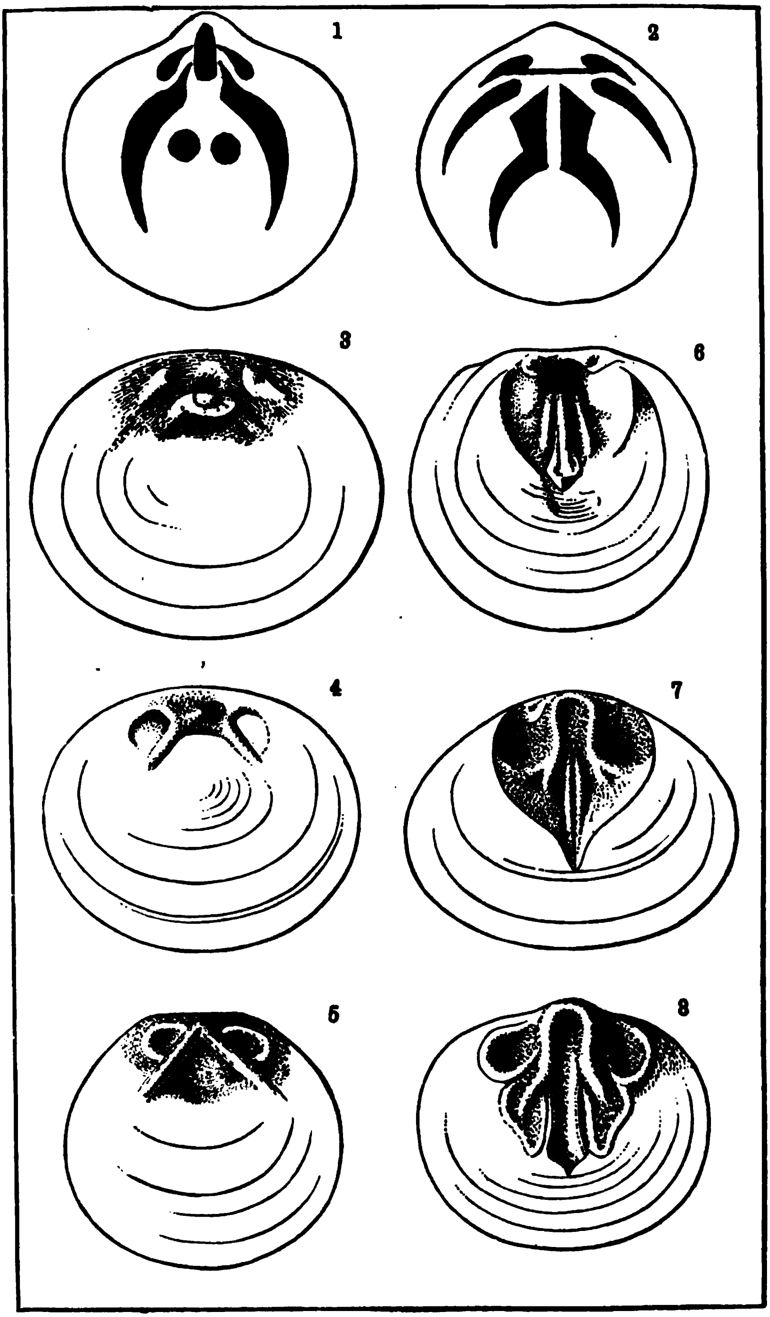
* Brach. Paradoxides beds of Sweden, 1876, pl. iii, figs. 36–41.

† Bull. Geol. Soc. France, 2d ser., vol. xvii, pl. viii, fig. 5.

‡ The genus Obolella. This Journal, vol. xxi, p. 131, 1881.



Discina Acadica Hartt is now referred to the genus *Stenotheca.* When examining specimens of *Stenotheca rugosa* Hall, sp., from the Georgian horizon at Troy, New York, in the collection of Mr. S. W. Ford, I noticed compressed specimens that are almost identical in appearance with the type of Professor Hartt's species now before me. Mr. R. P. Whitfield* called attention to this resemblance, believing that *D. Acadica* was the impression of a univalve shell of the genus *Palæacmea* or *Stenotheca.*

DESCRIPTION OF FIGURES.

Fig. 1. Plan of the interior of the dorsal valve of *Obolella chromatica* as determined by Mr. Billings. Fig. 2. Ditto of the ventral. Fig. 3. Outline of the interior of the ventral valve of *Linnarssonia transversa;* the apex of the triangular-shaped projection in front of the foraminal opening is broken off. Fig. 4. Cast of the interior of the ventral valve of ditto. Fig. 5. Cast of the interior of the ventral valve of *L. sagittalis,* after Davidson. Fig. 6. Interior of the dorsal valve of *L. transversa,* as shown in a flattened specimen. Fig. 7. Cast of the interior of the dorsal valve of an uncompressed example of *L. transversa.* Fig. 8. Cast of the interior of the dorsal valve of *L. sagittalis,* after Davidson.

ART XIX.—*On the Rotation of the Equipotential Lines of an Electric Current by Magnetic Action*; by E. H. HALL, Instructor in Physics at Harvard College.

IN this article the results will be given of experiments made during the month of August, 1883, and at intervals since, in the Physical Laboratory of Harvard College. The substances which have been chiefly examined are copper, zinc, certain of their alloys, and iron and steel. Some mention will be made also of gold, cobalt, nickel, bismuth and antimony. In most cases when possible the metal was used in the form of a thin strip about 1·1 cm. wide and about 8 cm. long between the two pieces of brass B, B (fig. 1), which soldered to the ends of the strip served as electrodes for the entrance and escape of the main current. To the arms *a*, *a*, about 2 mm. wide and perhaps 7 mm. long, were soldered the wires *w*, *w*, which led to a Thomson galvanometer. The notches *c*, *c*, show how adjustment was secured. The strip thus prepared was fastened to a plate of glass by means of a cement of beeswax and rosin, all the parts shown in the figure being imbedded in and covered by this cement, which was so hard and stiff as to be quite brittle at the ordinary temperature of the air.

The plate of glass bearing the strip of metal so imbedded was, when about to be tested, placed with B, B, vertical in the narrow part of a tank whose horizontal section is shown in fig. 2. This tank T T containing the plate of glass with the metal strip was placed between the poles P, P, of the electromagnet. The tank was filled with water which was sometimes at rest and sometimes flowing. By this means the temperature of the strip of metal was under tolerable control and the inconvenience from thermoelectric effects at *a* and *a* considerably lessened. The diameter of the plane circular ends of the pole pieces P, P, is about 3·7 cm.

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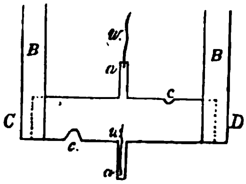
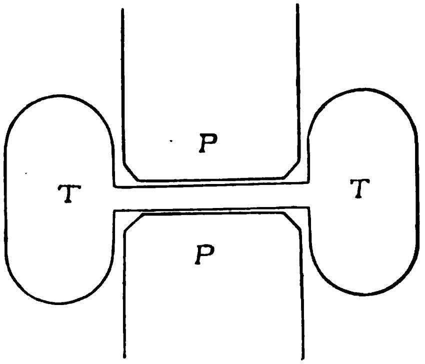
* Bull. Amer. Mus. Nat. Hist., vol. i, p. 140.

1.



2.



The general method of most of the experiments to be mentioned did not differ much from that described in this Journal for September, 1880. The intensity of the magnetic field was estimated as before, by the impulse given to a galvanometer needle when a small coil in connection with the galvanometer was suddenly removed from the field. This impulse was compared with that given to the same needle by the current obtained by turning an earth inductor of known dimensions.

The direct current through the strip under examination was measured by means of a tangent galvanometer. The transverse current was measured by means of a Thomson galvanometer, the reduction factor of this instrument usually being determined by passing through it a current of known strength a few minutes before and a few minutes after each set of observations on the transverse current.

The rotational powers will, then, be given in ostensibly absolute measure, but an uncertainty of several per cent attaches to the values given owing to uncertainty in regard to the following quantities: 1st, the thickness of the strips examined; 2d, the dimensions of the small test coil used for getting strength of magnetic field; 3d, the horizontal intensity of the earth's magnetism; 4th, the reduction factors of the tangent galvanometer used; 5th, the magnitude of the direct effect exerted by the electromagnet upon the Thomson galvanometer at a distance of about 50 feet.

One of the most troublesome operations in these experiments is that of determining the thickness of the metal strips examined. Owing to the inevitable slight roughness of the surface, direct measurement with calipers is likely to give too great a thickness. On the other hand the density of many specimens is subject to considerable uncertainty and, therefore, the indirect method by means of weight and density, which is the method used, cannot be applied with full confidence. Moreover the latter method gives, at best, only the average thickness of the strip, whereas I have heretofore assumed, and in this article still assume, that the effective thickness of the strip is the thickness of that part which lies between the two arms *a*, *a*. My practice of late has been, therefore, to determine the average thickness by the weight and density method, making use of the best data available, and to estimate the thickness between the arms by adding to, or subtracting from the average thickness, according as the calipers indicated the thickness at that place to be greater or less than the average. In case of several of the strips to be mentioned hereafter this correction was somewhat carelessly made and there may be an inaccuracy of four or five per cent in the estimated "effective thickness." With other strips much care was taken in this respect and it is believed that the uncertainty in regard to the density of the metal is the greatest source of error in determining the thickness in these cases. Particulars will be given as the strips are in turn described.

The 5th source of error was very troublesome in the experiments upon certain alloys. The galvanometer was unfortunately so placed that not only the magnitude but even the direction of this effect of the electromagnet might be varied when by any means the galvanometer needle was turned a few degrees from its ordinary position of rest.

COPPER, ZINC AND THEIR ALLOYS.

More than three years ago (B. A. Report, 1881), I found that if the rotational power of copper is called −, that of zinc is +. At the same time a specimen of brass, exact composition unknown, had been found to lie between copper and zinc in this respect, but nearer the copper, having in fact a small − rotating power.

Through the kindness of Prof. Trowbridge and Mr. E. K. Stevens, I had at command in the summer of 1883 several alloys of copper and zinc in widely varying proportions. Specimens of these alloys had been analyzed chemically by Mr. Stevens, but as they had lain for some time in an exposed position after he had finished his work upon them, I feared the labels upon them might not be intact, and Mr. G. D. Moore of the Harvard class of 1884 has been kind enough to make new analyses for me, determining both the copper and the zinc in specimens furnished him in the form of thin strips such as were used in my own experiments. Mr. Moore found

Specimen.	Copper.	Zinc.
A	99·9 per cent.	----
B	81·08	18·51 per cent.
C	72·86	27·02
D	66·85	33·04
F	5·87	93·79
G	a trace	99·54

Specimen E which contained apparently about 50 per cent copper was so brittle that I did not succeed in getting it rolled into a thin sheet.

Most, if not all, of these specimens were annealed one or more times during the process of rolling. None of the strips examined, however, were annealed after the final rolling. All of the strips which were used were cut in such a way that the arms *a*, *a* extended in that direction in which the strips passed through the rolls.

As it is a somewhat troublesome matter to determine accurately the density of a thin strip of metal and as my immediate purpose did not demand great accuracy in this respect, it seemed allowable to estimate the density of the alloys from their composition. After certain rough experiments the density 8·9 was assumed for the copper, and 7·2 for the zinc. Assuming, what we know to be not strictly true, that the density of an alloy decreases regularly as its amount of zinc per unit mass increases, we find

Alloy.	Density.
B	8·6
C	8·4
D	8·3
F	7·3

The description of particular strips will now be given.

A. (No. 1.)

Length of main strip when weighed	4·20 cm.
Width of main strip when weighed	1·07 cm.
Area including that of the arms	4·98 cm. sq.
Weight	·202 grm.
Density	8·9
Average thickness from above	·00456 cm.

By calipers the thickness appeared to be at one end ·0046; other end ·0044; between arms ·0048; average ·0046. Take then for true thickness between arms ·00476.

The measurement with calipers in this case was not made with great care, and the correction here applied is open to some suspicion.

With this strip the space between the brass strips B, B (fig. 1) was about 3·2 mm.

B. (No. 1.)

Length of main strip when weighed	4·58 cm.
Width of main strip when weighed	1·08 cm.
Area, including that of the arms	5·32 cm. sq.
Weight	·184 grm.
Density	8·58
Average thickness from these data	·00403 cm.

From the indications of the calipers I concluded that the thickness between the arms was about 1½ per cent greater than the average thickness.

Hence thickness between the arms, ·00409 cm. This value, like that given for A, may be wrong to the extent of several per cent. Distance between strips B, B, about 3·2 cm.

C. (No. 1.)

Length of main strip when weighed	3·75 cm.
Width of main strip when weighed	1·08 cm.
Area of whole strip when weighed	4·39 cm. sq.
Weight	·1085 grm.
Density	8·44
Average thickness from these data	·00292 cm.

By calipers thickness at one end, ·0034; at other end, ·0032; between arms, ·0034; average, ·00333 cm. Take then for true thickness between arms ·00299 cm. Distance between strips B, B, about 3·2 cm.

D. (No. 1.)

Length of main strip when weighed	3·86 cm.
Width of main strip when weighed	1·07 cm.
Area of whole strip	4·45 cm. sq.
Weight	·1081 grm.
Density	8·33
Average thickness from these data	·00291 cm.

By calipers thickness at one end, ·0030; at other end, ·0030; between arms, ·0032; average, ·00307 cm. Take for true thickness between arms ·00304 cm. Distance between strips B, B, about 3·2 cm.

F. (No. 1.)

Length of main strip when weighed	3·70 cm.
Width of main strip when weighed	1·06 cm.
Area of whole strip when weighed	4·28 cm. sq.
Weight	·2915 grm.
Density	7·3
Average thickness from the data	·00934 cm.

By calipers thickness at one end, ·0098; at other end, ·0100; between arms, ·0100; average, ·00993 cm. Take for true thickness between arms ·00941 cm. Distance between strips B, B, about 3·2 cm.

G. (No. 1.)

Length of main strip when weighed	4·17 cm.
Width of main strip when weighed	1·09 cm.
Area of whole strip when weighed	5·03 cm. sq.
Weight	·1206 grm.
Density	7·2
Average thickness from these data	·00333 cm.

From a somewhat careful use of the calipers it appeared that the thickness between the arms was about 4½ per cent greater than the average thickness.

Take then for thickness between arms ·00348 cm. Distance between strips B, B, about 3·2 cm.

The main object in the experiments upon these metals and their alloys was to determine whether the alloys would range themselves according to any simple law so that the magnitude of the rotational power in any alloy might be inferred from its known proportions of copper and zinc. Some attempt was made, moreover, to determine the effect of change of temperature in different specimens.

It will be seen that the intensity of the magnetic field was kept nearly the same throughout the experiments of August upon copper, zinc, and their alloys. The strength of the direct current was, moreover, of about the same magnitude in all cases except the experiments of Aug. 11th on copper. On that day the current used was less than one half as strong as that used later. The same strip of copper was tested again Aug. 29th with a current of the usual strength and the agreement between the results obtained under so widely different conditions is quite close.

In the following table and throughout this article the C. G. S. system is used wherever no statement is made to the contrary. The following symbols used with the tables need explanation:

C means current along line C D (fig. 1).

M means intensity of magnetic field perpendicular to plane of paper in fig. 1.

R. P. means *rotatory power*, which is numerically defined by the expression $D\frac{E}{C \times M}$, in which D is the thickness of the metal strip, and E is the electromotive force resulting from C and M which maintains the *transverse* current.* The R. P. is considered *positive* when E is of such a character as to send a *positive* transverse current in that direction in which the conducting strip tends to move under the action of the main current and the magnetic force.

The temperatures referred to in the tables are those indicated by a thermometer placed in the water tank containing the plates when under examination (fig. 2).

Copper, Zinc, and their Alloys.

Strip.	Composition acc. to chem. anal.		Date.	Tem.	M	C	R.P. $\times 10^{15}$	R. P. near 24° C $\times 10^{15}$	Composition, etc.†	
	Percent Copper.	Percent Zinc.							P. c. Cop.	P. c. Zinc.
A	100		1883.							
	(99·9)		Aug. 11	3°C.	5700	·0619	(−521)			
"	"		"	4·8°	5640	·0819	(−530)			
"	"		"	21·5°	5560	·0876	(−520)	(−520)		
"	"		Aug. 29	24·5°	6030	·1906	(−519)			
B	81·3	18·7								
	(81·08)	(18·51)	Aug. 18	25°	5750	·1800	(−404)	(−404)	91·3	8·7
C	73	27								
	(72·86)	(27·02)	Aug. 17	5·1°	5680	·1810	(−246)			
"	"	"	"	22·8°	5700	·1830	(−250)	(—250)	80	20
D	67	33								
	(66·85)	(33·04)	Aug. 13	6°	5830	·1680	(−178)			
"	"	"	"	25°	5930	·1680	(−166)	(−166)	73.6	26·4
F	6	94								
	(5·87)	(93·79)	Aug. 17	4°	5640	·1790	(+527)			
"	"	"	"	24°?	5690	·1780	(+496)	(+496)	24·3	75·7
G	0·0	100								
	(trace)	(99·54)	Aug. 15	4·4°	6150	·1860	(+838)			
"			"	25°	6130	·1850	(+830)	(+820)		
"			"	22·4°	6210	·1870	(+809)			

This table shows the results of experiments with the metal strips thus far described in detail. The last two columns give approximately the composition of plates which would have the observed rotatory powers if copper and zinc in uniting retained their individual powers unaltered. It will be perceived that in every case the proportion of copper demanded upon this basis is greater than the proportion in the actual plate.

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* The R. P. of this article is the *reciprocal* of the quantity $\frac{M \times V}{E'}$ used in my article in the Amer. Jour. of Science, Sept. 1880.

† Composition of alloys which *à priori* might have been expected to have these values of R. P.

At the time these experiments were made I supposed plate B to contain about 92 per cent of copper, which would have furnished an exception to this rule. Thinking some serious error might have been made in estimating the thickness of this plate, or that of the copper plate or the zinc, I prepared with very great care plates No. 2 of A, B and G. These new plates were similar to those already described, but were in length between B and B about 2·2 cm. As the vacation was now over and my opportunities for experimental work were limited, I contented myself with making, in the main, comparative experiments with these plates. I did not redetermine the horizontal intensity of the earth's magnetism and I made no attempt to determine the direct effect of the electromagnet upon the Thomson galvanometer with which the transverse current was observed. I knew that this direct effect was small and I endeavored to arrange matters in such a way that it would affect all the new results with A, B and G in the same direction and to nearly the same extent. The intensity of the magnetic field in the experiments with these plates was about the same as in the previous experiments with the alloys. This intensity was determined as usual on October 20th, when the effect of change of temperature upon the plate B No. 2 was tested, but on October 13th, when A No. 2 and B No. 2 were compared, and on October 27th, when A No. 2 and G No. 2 were compared, this determination was not considered necessary. On October 13th A No. 2 was tested first, then B No. 2, then A No. 2 again. This arrangement tended to make the result of the comparison independent of any progressive diminution in the strength of the current operating the electromagnet, and it saved much time. On October 27th the same method was followed.

I shall not attempt to give the result of these experiments in absolute measure, but shall write the results obtained on an arbitrary scale.

Specimen.		Per cent of Copper.	Per cent of Zinc.	Temp.	R. P.
A.	No. 2.	99·9	----	----	100(−)
B.	"	81·08	18·51	21°	76·1(−)
"	"	"	"	4°	78·7(−)
G.	"	....	99·54	----	158·8(+)

A No. 2 and B No. 2 were compared at about 25° C., A No. 2 and G No. 2 at about 19° C.

The values of R. P. given in the first table are in the following proportion:

	R. C.
A No. 1.	100 (−)
B "	77.6 (−)
C "	157·5 (+)

This agreement was regarded as highly satisfactory, all things considered, and the apparent exception which, as stated above, had been noted in the case of B appeared to be confirmed. The result of the chemical analysis, however, showed that this alloy, which according to the label found upon it contained nearly 92 per cent of copper, really had the composition given in the tables above. Alloy B, then, does conform to the rule that the alloys of copper and zinc have rotating powers nearer to that of copper than the composition of the alloys would have led one to expect.

INFLUENCE OF TEMPERATURE.

It will be seen that in the case of copper, zinc and all the alloys except C, a fall of temperature appears to cause a slight increase in the numerical value of of the rotating power. It is possible that upon further trial the apparent exception furnished by C would disappear. It does not, on the other hand, seem probable that the agreement in a particular direction of five cases out of six is entirely accidental. In the case of D the apparent change caused by fall of temperature is very considerable, but the observations made with this alloy were particularly unsatisfactory, the needle of the Thomson galvanometer being quite unsteady, while the total effect to be measured was small.

The experiments upon iron and steel were in the main repetitions of those already published, but made with more care.

SOFT IRON.

The dimensions of the strip of soft iron used in the experiments were roughly as follows:

Length between terminals B, B, (fig. 1),	2·9 cm.
Width,	1·06 cm.
Thickness,	·0041 cm.

Like the strip used in 1882* it was obtained through the kindness of Prof. Langley of the Allegheny Observatory, and the two strips had probably nearly the same composition and character.

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* This Journal, March, 1883.

Although the test made in 1882 was not satisfactory, it seemed to me to indicate that the R. P. of soft iron was slightly greater at high than at low magnetic intensities, and I hazarded the opinion that future experiments would prove this to be the case. This opinion has scarcely been justified by the result. The table given below does indeed appear to indicate a very slight increase in the R. P. as M rises from 801 to 3264 and again as M rises from 3264 to 5835, but the increase in the numbers as observed is too slight to deserve any confidence.

Date.	Temp.	M.	C.	R.P.	Estimated R.P. at 28°.
Aug. 22, '83.	6·2°	791·4	·1771	$+7147\times10^{-15}$	
"	28·2	797·6	·1742	+8302	
"	28·3	804·6	·1794	+8304	
	28·25	801·1		8303	$+8290\times10^{-15}$
Aug. 23.	28·1	3259	·1728	8306	
"	28·4	3274	·1702	8289	
"	27·65	3260	·1696	8306	
	28·05	3264		8300	$+8297\times10^{-15}$
Aug. 24.	28·7	5797	·1839	8391	
"	28·1	5833	·1842	8310	
"	28·0	5875	·1853	8245	
	28·27	5835		8315	$+8300\times10^{-15}$
Aug. 27.	27·25	8626	·1894	8139	
"	28·35	8690	·1898	8261	
"	27·95	8636	·1911	8200	
	27·85	8651		8200	$+8208\times10^{-15}$

Fall of R. P. for 1° fall of temperature equals approximately ⅔ per cent.

On the other hand the decrease in the observed value of the R. P. as M rises from 5835 to 8651, though slight, seems to me strong evidence of an actual falling off in the value of the R.P. of iron at high magnetic intensities.

In any case it appears, and this was one of the important questions to be answered by the experiments, that the R. P. of iron under magnetic forces of varying intensity is more nearly constant than the R. P. of nickel, for according to previous experiments* the R. P. of nickel in a magnetic field of intensity 8700 is many per cent, perhaps 20, less than in a magnetic field of intensity 2000.

The one trial made at low temperature confirmed the inference drawn from a similar trial made the year before,† that a fall of 1° C. diminishes the R. P. in soft iron about ⅔ per cent. It is with these experiments as a basis that I have ventured to make the slight changes necessary to deduce from the observed results the values of the R. P. at 28°.

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* Phil. Mag., Sept., 1881.

† This Journal, March, 1883, p. 218.

A test was made with this strip of soft iron for a permanent change in the direction of the equipotential lines. A similar experiment with tempered steel the year before had been successful and the description of the method I will quote from a previous article (this Journal, March, 1883). "This plate, with the usual electrical connections, and with a current flowing through it, was placed in the usual position between the poles of the electromagnet, the magnet current was turned on, then off, and the plate removed from between the poles in order to avoid the action of the very considerable residual magnetism of the electromagnet. A reading of the Thomson galvanometer in the transverse circuit was now made, then the plate was replaced between the poles and the current turned on again but in the opposite direction. The magnet current being again interrupted, the plate was again removed from the field and another reading of the Thomson galvanometer was made." Making this experiment with the soft iron and with a battery of 50 cells, the result was a negative one. If any permanent effect was produced, it was probably a small part of one per cent of the temporary effect produced while the plate was subjected to the magnet's action.

STEEL.

The steel used in this series of experiments was obtained from Montgomery & Co., New York, and was designated by the letters "F. C. R." which stand for "French Cold Rolled." This steel as it came from the dealers was pliable and soft enough to be quite readily cut with a pocket knife. The first strip to be described was tested in this "natural" condition.

No. 1 (*untempered.*)

Length of main strip when weighed	4·13 cm.
Width of main strip when weighed	1·10 cm.
Area of whole strip when weighed	4·88 sq. cm.
Weight	4·21 grm.
Density	7·9
Average thickness from these data	·01092 cm.
Estimated thickness between arms	·01116 cm.
Distance from B to B, about	3·1 cm.

No. 2 (*tempered.*)

The dimensions of this strip were not so carefully taken. It was so brittle that I felt obliged to use caution in applying the calipers to it. It appeared to be of about the same thickness as No. 7 and I assumed it to have exactly the same thickness. The distance from B to B was about 2·6 cm.

Results obtained with these two strips are shown in the following table:

	Date.	Temp.	M.	C.	R.P.
No. 1.	Nov. 24.	18·7°	1647	·0970	$+12000 \times 10^{-15}$
"	"	2·5	1629	·1007	$+11230 \times$ "
		16·2			770

Decrease for 1° fall of temperature, approximately ·4 per cent.

	Date.	Temp.	M.	C.	R.P.
No. 2.	Dec. 1.	18·°	1602	·0870	$+32720 \times 10^{-15}$
"	"	1·9	1587	·0908	$+30800 \times$ "
		16·1			1920

Decrease for 1° fall of temperature, approximately ·4 per cent.

The magnitude of the rotational coefficient in the soft steel is about 1½ times, and that in tempered steel about 4 times as great as that in the soft iron. This agrees very well with the conclusion drawn from the hasty experiments of the year before, when a piece of steel from a clock-spring was used. When a sensitive galvanometer is used, an ordinary permanent horse-shoe magnet of half inch bar produces an easily discernible effect in the strip of tempered steel.

It should be stated that two or three months before the trials which furnished this table were made, both these steel strips had been subjected, in the usual position, to a magnetizing force of about 8500 intensity. It does not seem probable that the results just recorded were seriously affected by this previous experience of the steel.

This first magnetization was for the purpose of detecting, if possible, a *permanent* effect, such as had been observed a year before in a piece of tempered clock-spring, but had been vainly looked for in soft iron.

No. 2 showed a permanent effect equal to about 1½ per cent of the temporary effect, a result agreeing very well with that obtained with the tempered clock-spring. No. 1 showed a permanent effect relatively, and even absolutely, larger than that in No. 2. It was about 5 per cent of the temporary effect. In both cases the tests made were hasty, and the results obtained are only approximately correct. I believe it has been observed that residual magnetization is, under certain conditions, greater in soft than in hard steel.

GOLD.

The only experiment of importance made with gold was a test for permanent effect. The strip used was the one experimented with the year before, a description of which has already been published (this Journal, March, 1883). The permanent effect, if any was produced, must have been a very small part of one per cent of the temporary effect.

Cobalt.

In the Philosophical Magazine for September, 1881, I said, "No thin strips of the metal [cobalt] being at hand, a slice was sawn from a small block of moderately pure cast cobalt and worked into the form of a cross. To the extremity of each arm of this cross was soldered a thin strip of copper . . . . for the purpose of making the electrical connections. The cross of cobalt with the copper strips attached was now fastened with hard cement [beeswax and rosin] to a strip of glass," etc. It was the same piece of cobalt, reduced now with file and emery paper to a thickness of about ·0062 cm., that served during this new series of experiments. The central portion of the cross was about 2 mm. square, and the arms, about 3 mm. long and 2 mm. wide, projected from it at right angles.

The main object of the recent test was to determine the effect produced in cobalt by change of temperature. It is assumed that the intensity of the magnetic field remained constant during these experiments. It is possible, however, that it diminished one or two per cent during the series. The error introduced in this way is of slight consequence for the present purpose. Again, the direct effect of the electromagnet in disturbing the needle of the Thomson galvanometer was neglected, together with certain other particulars which may have introduced a constant error of several per cent into the values obtained for the rotatory power.

No. of Exp.	Date.	Temp.	M.	C.	R.P.
1.	Dec. 22, '83.	3°	3463	·1251	$+2092 \times 10^{-15}$
3.	"	1·3°	"	·1243	+2061
		2°			2076
2.	"	18°	"	·1238	+2441
4.	"	"	"	·1244	+2390
		18°			2415

Decrease of R. P. for fall of 1° C. is approximately $\frac{8}{10}$ per cent.

Bismuth.

I can only confirm what Prof. Righi* has already published concerning the rotational effect in this metal. The rotational power appeared to be about 260 times as great numerically as that of tempered steel and of the opposite sign.

The slice of bismuth used was obtained, shaped and mounted in much the same manner as the slice of cobalt already described. The length and breadth of the bismuth cross were somewhat greater than the corresponding dimensions of the cobalt and the thickness was about 1 mm.

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* Acc. dei Lincei Transunti, June, 1883.

It seems probable that a thin slice of bismuth, properly prepared and mounted, will come to be a valuable instrument for measuring the intensity of strong magnetic fields.

ANTIMONY.

The powerful effect observed in bismuth suggested an examination of antimony. A slice of this metal much like the slice of bismuth just mentioned was prepared. The cross suffered in shape a good deal in making the adjustment. The final average thickness in the central portion was estimated at 1·2 mm.

Date.	Temp.	M.	C.	R.P.
1884, July 26th,	21·8°	1696	·1150	$+114100\times10^{-15}$
Aug. 8th,	21·1°	1638	·1104	$+117300\times$ . . .
Aug. 8th,	3°	1638	·1104	$+123900\times$ . . .

The two trials of August 8th were not entirely independent of each other, as only one test of the intensity of the magnetic field and of the sensitiveness of the Thomson galvanometer was made during the two trials of that date. The results as they stand indicate an increase of the rotational power with fall of temperature, but the experiments were too hasty to justify a conclusion upon the matter.

Several experiments have resulted from the criticisms or suggestions of other investigators.

MR. BIDWELL'S THEORY.

This has been so recently and so widely published that it is hardly necessary for me to state it in detail.

In *Science* (March 28th, 1884), I replied very briefly to Mr. Bidwell's first paper, stating that I found the transverse current in a strip of soft steel to be in the same direction when the strip was fastened to the supporting plate by a clamp across the middle of the strip only, as when it was fastened by means of clamps at its ends only.

Mr. Bidwell has in his second paper (Phil. Mag., April, 1884), described an experiment which he appears to consider conclusive against the previously accepted view of the "rotational effect." In brief he obtains what he calls a "reversal" of the transverse effect in gold, using a strip of that metal having two narrow longitudinal slits lying on the same straight line and nearly meeting in the center of the strip.

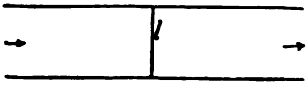
I shall not undertake here an extended discussion of this interesting experiment of Mr. Bidwell. My view of the matter is in substance as follows:

Let *l* in fig. 3 represent an equipotential line in a strip of metal through which an electric current is flowing, the metal being in a normal condition.

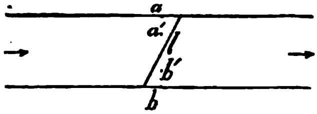
In fig. 4, *l* represents the corresponding equipotential line when the metal strip is acted upon by a powerful magnetic force in a direction perpendicular to the plane of the paper.

If now *a* and *b* be connected by means of a wire, a current will flow from *a* to *b* through the wire. If *a′* and *b′* be connected in the same way, a weaker current will flow from *a′* to *b′* through the wire.

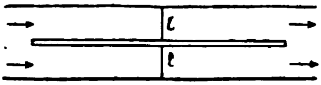
3.



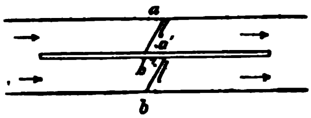
4.



5.



6.



7.

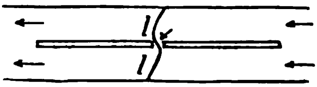


Fig. 5 represents a metal strip having along its middle a slit longer than the diameter of the magnetic poles between which the slit is placed, *l* and *l* being corresponding equipotential lines when the strip is in its normal unstressed condition.

Let a magnetic force act as before. Each of the lines *l*, *l* in fig. 5 is rotated about its center through the same angle as *l* in figs. 3 and 4. The result is shown in fig. 6.

If now *a* and *b* be connected by means of a wire a current will flow from *a* to *b* through the wire. If *a′* and *b′* be connected in same way a current will flow from *b′* to *a′* through the wire.

To get Mr. Bidwell's case, imagine a narrow bridge of metal to be left crossing the slit between *a′* and *b′*. Such a bridge would serve as a shunt to the wire which we have imagined connecting *a′* and *b′* but would not reverse the relative potentials of these two points. The lines *l*, *l*, as Sir Wm. Thomson pointed out at the Philadelphia meeting, would now take a form something like that shown in fig. 7.

As the bridge across the slit becomes wider such lines as *l* will become more nearly straight till finally the condition of things represented in fig. 4 will be practically reproduced. On the other hand if the slit in fig. 5, were short compared with the width of the poles of the magnet, a *reversal* such as Mr. Bidwell detected should not occur.

MR. TOMLINSON'S SUGGESTION.

In the Philosophical Magazine for May, 1884, Mr. Tomlinson stated that certain relations which he had discovered indicated that the rotational effect in nickel should be greater at low than at high temperatures. He therefore called in question the conclusion to the contrary which I had drawn from certain hasty and very rough experiments made before the use of the water tank gave me the means of easily controlling the temperature of the metal under examination. I have, therefore, recently taken up the matter again. I used the same piece of nickel with which the former test was made (Phil. Mag., Sept., 1881, p. 163), but the strip was now so much damaged while being fastened upon glass that it was necessary to cut its width down a good deal in order to obtain the "arms" for the side connections. The following table shows the results obtained.

No. of exp.	Date.	Temp.	M.	C.	R.P.
1	July 28, '84.	22°	1717	·03074	14940×10^{-15}
2	"	4·9°	1703	·03135	13760 "
3	" 29,	20·5°	1652	·03140	14710 "
4	" 30,	2·2°	1636	·03123	12810 "
5	" "	21·2°	1629	·03121	15060 "
6	Aug. 1,	2·8°	1671	·03137	13180 "
7	" 4,	26·1°	1691	·03140	15110 "
8	" "	4·1°	1627	·03112	13220 "

Combining the 1st, 3d, 5th and 7th, we have

Temp.	R.P.
22·5°	14960×10^{-15}

From the 2d, 4th, 6th and 8th we have

3·5°	13240×10^{-15}

Decrease for 1° fall of temperature = approximately .6 per cent.

It will be noticed that the results obtained at low temperatures do not accord so well as those at high temperatures. This fact is in all probability due to the difficulty experienced in preventing slight fluctuations of temperature while the colder water was flowing through the tank. Irregularity in the flow of this water causes disturbing thermo-electric currents.

The quantity called R. P. in this paper corresponds to the $\frac{E'}{V}$ of my 1881 paper divided by the F of that paper. Calculating the R. P. of nickel from the 188 experiments I find it to be about 12700×10^{-15}, for a field of intensity 1660. In looking about for an explanation of this disagreement I found that the thickness of the strip had been called ·00104 cm. in 1881, and ·0012 cm. in the later experiments. The former estimate was obtained by weight, the latter by measurement with calipers. The difference accounts well enough for the different values obtained for the R. P. Which estimate of the thickness is the more reliable I will not undertake to decide.

Summary.

	$10^{15}\times$ R.P. at 20°C.
Copper	-520
Zinc	$+820$

Four alloys of copper and zinc were tested. If a series be made beginning with zinc and ending with copper, the four alloys being ranged between according to composition, the series thus formed will be the same as that obtained by ranging these metals and alloys according to the algebraic magnitude of their R. P's. In the alloys, however, the R. P's, are algebraically somewhat nearer that of copper than might be expected from the composition.

Iron	$+7850$

R. P. nearly constant through wide range of magnetic intensity but apparently decreasing slightly at high intensities.

No ascertained *permanent* effect.

Steel, *soft*	$+12060$

Permanent effect about 5 per cent of temporary effect.

Steel, *tempered,*	$+33000$

Permanent effect about 1½ per cent of temporary effect.

Gold (no new test of magnitude of R. P.)	-660

No ascertained permanent effect.

Cobalt	$+2460$
Nickel	-14740
Bismuth	-8580000
Antimony	$+114000$

A fall of 1° C. in temperature causes

in the R.P. of Iron,	a fall of	⅔	per cent approx.
Steel, soft,	"	⅓	"
Steel, temp'd,	"	⅓	"
Cobalt,	"	1	"
Nickel,	"	⅔	"

Non-magnetic metals, apparently a small increase.

APPENDIX.

At the Philadelphia meeting of the American Association I stated that I had compared the behavior of a strip of soft steel cemented to a plate of glass with that of a similar strip fastened to a plate by means of a clamp. In preparing the matter for publication, however, I found that the test had not been made so carefully as was desirable, and I have therefore just repeated the experiment with the assistance of Mr. W. A. Stone, of the Harvard class of 1886.

I shall call the cemented strip A. It has been already mentioned as No. 1 in the preceding article. The clamped strip I shall call B. Both strips were cut from the same sheet of soft steel. Each is about 1·1^{cm} wide and 3·2^{cm} long between the terminals of brass. A is about ·011^{cm} thick and possibly a few per cent thicker than B. A suffered rather more than B in the process of adjustment (fig. 1).

A was not only fastened to its plate with the cement of beeswax and resin, but was imbedded in the cement, the latter covering it with a layer probably a millimeter or more in thickness. The plate was not placed in water for this test. The bearing of the clamp which fastened B to its plate was of wood, possibly a millimeter wide, and extended nearly from arm to arm of the strip. To prevent any very great bending each end of the strip was loosely tied to the plate with a piece of twine. Otherwise the strip was free and was exposed to the air.

The measurements recorded below were made between five and six o'clock, January 17th. There was an interval of one minute between successive readings of the Thomson galvanometer. No measurement of the intensity of the magnetic field was made. It is assumed that this intensity during the one trial of A, which was made between the two trials of B, was equal to the mean intensity during these two trials.

The signs + and − refer to the direction of magnetization, R and L to direction from the zero point of the Thomson galvanometer scale. The zero position of the index in these experiments was a considerable distance to the right of the zero of the scale. The tangent galvanometer measured the direct current through the strip.

	Thomson Galv.			Tangent Galv.
				74·0°
	+	−		73·9
	53 R			73·7
Strip B.	52 "	0		73·7
	51 "	3 R		73·6
	52 −	1·5	= 50·5	73·8, tan. = 3·44

			74·9°
			74·8
	43 R	8·0 L	74·7
Strip A.	43 "	6·5 "	74·7
	43 "		74·6
	43 +	7·2 = 50·2	74·7, tan. = 3·66

			73·7°
			73·6
	54·5 R	7·0 R	73·5
Strip B.	53·0 "	7·5 "	73·4
	52·5 "		73·3
	53·3 −	7·2 = 46·1	73·5, tan. = 3·38

From 2d we have

$$\text{A.} \qquad 50{\cdot}2 \div 3{\cdot}66 = 13{\cdot}7$$

From 1st and 3d,

$$\text{B.} \qquad \frac{50{\cdot}5+46{\cdot}1}{2} \div \frac{3{\cdot}44+3{\cdot}38}{2} = 14{\cdot}2$$

Of course absolute agreement in so rough a test was not to be expected. The difference of about 3 per cent here observed might easily be accounted for. I think Mr. Bidwell will admit that his theory would have predicted a different result of the comparison.

Cambridge, January 19, 1885.

ART. XX.—*On the use of the term Esker or Kăm Drift;* by J. HENRY KINAHAN.

FROM the papers read at the British Association Meeting at Montreal it is evident that the American geologists classify, under the names of Eskers and Kăms, gravels that are not so classified in Ireland.

These two words are Celtic. Căm, Kăm or Kăme, should be pronounced short. Kāme, the lowland Scotch and English pronunciation, is incorrect. Curiously the English river Căm is pronounced right; while the town on it, usually, although not always, is pronounced wrong, Cāmbridge.

Căm or Kăm means *crooked* or *winding*. In Ireland and England this name is generally used in reference to a winding river; but in the former it is also sometimes used in reference to winding ridges, or a winding or wrinkled structure; thus ophiolyte is called serpentine in English on account of its structure but in Ireland it is "Cămstone." This latter name for serpentine is now nearly obsolete, except in parts of Ulster, where an impure steatyte with a wrinkled structure is still called *Cămstone.*

Eiscir, pronounced Esker, is a well defined but small ridge. A nearly continuous ridge of gravel—Kăms—extends from Dublin to Galway, dividing Ireland into two nearly equal portions. This ridge, when Ireland, in the early historic period, was divided into two kingdoms, was taken as the divisional line; and hence the term Esker has generally been used in that country in place of Kăm, to designate the winding or crooked ridges of gravels, which in Scotland still retain commonly the more correct name of Kăm. Although in America the pronunciation Kām seems some way to have become general, yet, as far as my experience in Scotland goes, the word is generally pronounced Kăm.

True Esker or Kăm drift comprises more or less winding or crooked ridges and irregular hills of sands and gravels, due to the current and eddies generated by the meeting or colliding of two or more currents in a mass of water, such as that of a sea or large lake. Wind-driftage may also aid in forming esker sands, as for instance the long irregular ridges and hills constituting in many places the dividing ridge between a lagoon and a sea, where there is a rise and fall of tide: that is, a colliding of two or more currents;—in a tideless sea the enclosing materials of the lagoons are of a quite different nature from Esker or Kăm drift. In the dividing bars between a tidal sea and a lagoon the combination of the water and wind drifts are very interesting; high tides accumulating layers of gravel (fine or coarse) to be covered up by layers of fine sand due to the wind driftage.

The normal esker drift-ridges that are solely due to the colliding of currents in a mass of water, or those combined with wind-driftage, have a peculiar character of their own and should not be again confounded, as they were formerly, with other gravel and sand hills, such as the subaerial gravels on hill slopes, due probably to the water given off from a névé or mass of ice on a hill, during the summer; or the long regular ridges in valleys, due to excessive or sudden floods.

There are, both in the United States and the adjoining Canadian prairies, ridges of drift somewhat like the Irish Eskers, but at the same time totally different from them. What they are due to would be presumptuous in me to say, but they seem to be adjuncts of the great glacial moraines, because, as far as I was able to study them, they appear to be in connection with the breasts or marginal faces of such accumulations; as if for some reason, to me unknown, there were at times "flashes," or areas of shallow water, accumulated margining the faces, portions of which were still water, while in other portions there were currents; or it might have been a mass of snow margining a narrow flash of flowing water. This latter suggestion is put forward on account of what can be seen, but on a very small scale, in some of the Irish mountains, but more largely in some of the valleys of the Canadian Rockies. If such is their origin they may be considered in part allied to true eskers.

The above notes are written because it appears that American observers are unwittingly confounding the true Esker drift with the others which are more or less similar; and as the writer was the first, or one of the first, who pointed out the very different, but in some cases, rather similar drifts, that were gradually being included under the terms, As or Ősar, Esker, Cam, Kam, Kaim, Kame, all of which are names for the one and the same class of drift, he may perhaps be excused for drawing attention to the subject.

Esker or Kăm drift *par excellence* occurs in narrow, well defined, winding ridges, on a more or less level tract or area, and in such an area they are all on or at about one altitude, such as we might expect to find near the margin of a sea or large lake; while ridges of gravel running down a steep slope or the slope of a valley must necessarily have quite different origins. Up in valleys near their terminations, or in tributary valleys, there are other ridges that are very nearly allied to Eskers, they having originally been the marginal barriers of a lagoon; but if you take the outward appearance of true Eskers, combined with their peculiar internal structure, there is nearly invariably a marked difference between them and any other gravel accumulations. The writer of this has very fully gone into the subject of the Irish Eskers in a paper on "The Eskers of the Central Plain of Ireland," Dublin Geol. Soc., vol. x, or the Dublin Quarterly Journal of Science, vol. iv, and in the Geology of Ireland, Chap. xv, page 251, etc.

Ramelton, Co. Donegal, Dec. 10, 1884.

ART. XXI.—*On the Cause of Mild Polar Climates;* by JAMES CROLL, LL.D., F.R.S.

[Continued from page 29.]

Influences of Eccentricity during the Tertiary Period.—This being the state of things on the southern hemisphere, the glacial condition of the hemisphere, when its winter solstice was in aphelion, would tend in a powerful manner to impel the warm water of the south over on the northern hemisphere, and thus raise its temperature. This, again, is a view which has also been urged by Mr. Wallace. "Though high eccentricity would," he remarks, "not directly modify the mild climates produced by the state of the northern hemisphere which prevailed during Cretaceous, Eocene, and Miocene times,* it might indirectly affect it by increasing the mass of antarctic ice, and thus increasing the force of the trade-winds and the resulting northward-flowing warm currents. . . . . And as we have seen that during the last three million years the eccentricity has been almost always much higher than it is now, we should expect that the quantity of ice in the southern hemisphere will usually have been greater, and will thus have tended to increase the force of those oceanic currents which produce the mild climates of the northern hemisphere" (p. 192).

There is little doubt but that the climate of the Tertiary period was greatly affected by eccentricity; but, owing to the difference in the geographical conditions of the two hemispheres, eccentricity would exercise a much greater influence on the climatic condition of the northern hemisphere when the northern winter solstice was in perihelion than it would do when it was in aphelion. Owing to the difference in the conditions of the two hemispheres, the physical agents brought into operation by a high state of eccentricity would act more powerfully in impelling the equatorial waters toward the arctic regions when the winter solstice was in perihelion than they would do in impelling the waters toward the antarctic regions when the solstice was in aphelion. In this case the northern hemisphere would be heated to a greater extent when its winter solstice was in perihelion than it would be cooled when the solstice was in aphelion. It is this circumstance which, I think, has misled geologists, and induced them to conclude that because the physical agents brought into operation when the winter solstice was in aphelion, during a high state of eccentricity, failed to produce a well-marked glacial epoch in

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* High eccentricity might not directly modify the mild climates, but certainly the physical agents brought into operation by the high eccentricity would do so.

Tertiary times, that consequently the climatic condition of that period was not much affected by eccentricity.

It would seem to be owing to that peculiar difference between the conditions of the two hemispheres that, even during high eccentricity, the physical agents in operation when the winter solstice was in aphelion were unable to lower the temperature of the northern hemisphere to the extent sufficient to cover high temperate and arctic regions with permanent ice; but for this very same reason these agents would be enabled to raise the temperature to an extent exceptionally high when the winter solstice was in perihelion. In other words, this very combination of circumstances, which so much modified the severity of what may be called the Tertiary cold periods, intensified to an exceptionally great extent the warmth and equability of what may be called the Tertiary warm periods.

Climate of the Tertiary Period, in so far as affected by the Eccentricity.—If the foregoing conclusions are correct, the following would then seem to be the probable character of the climate of the Tertiary period, in so far as that climate was affected by eccentricity. As is truly remarked by Mr. Wallace, the eccentricity during the past three million years has been almost always much higher than it is now. It will consequently follow that very considerable portions of the Tertiary age would consist of alternate comparatively cold and exceedingly warm and equable periods. These may be said to correspond to the cold and warm periods of the glacial epoch; but, of course, they could in no sense be called glacial and interglacial periods; for the cold of the cold periods would not be such as to produce permanent ice, while the heat and equability of the warm periods would far exceed that of the interglacial periods.

Evidence of such Alternations of Climate.—That such oscillations occurred during the Tertiary period seems to be borne out by the facts of geology and palæontology. Mr. J. Starkie Gardner, a geologist who has had great experience in the fossil flora of the Tertiary deposits, says that such alternating warmer and colder conditions is supported by strong negative and some positive evidence, found not only in English Eocene, but in all Tertiary beds throughout the world. In the Lower Bagshot of Hampshire have been found, he states, feather- and fan-palms, *Dryandra*, beech, maple, *Azalea*, laurel, elm, acacia, aroids, cactus, ferns, conifers, *Stenocarpus*, and plants of the pea tribe, together with many others. The question which presents itself to one's mind, he remarks, is, how is it possible that the tropical forms, such as the palms, aroids, cactus, etc., could have grown alongside of the apparently temperate forms, such as the oak, elm, beech, and others? Mr. Gardiner's explanation is as follows:—

"Astronomers, having calculated the path of the revolution of the earth in ages past, tell us that in recurring periods each hemisphere, northern and southern, has been successively subject to repeated cyclical changes in temperature. There have been for the area which is now England many alternations of long periods of heat and cold. Whenever the area became warmer, the descendants of semitropical forms would gradually creep farther and farther north, whilst the descendants of cold-loving plants would retreat from the advancing temperature, *vice versâ.* Whenever the area became gradually colder, the heat-loving plants would, from one generation to another, retreat farther and farther south, whilst the cold-loving plants would return to the area from which their ancestors had been driven out. In each case there would be some lingering remnants of the retreating vegetation (though perhaps existing with diminished vigor) growing alongside of the earliest arrivals of the incoming vegetation.

Such is a possible explanation of our finding these plant-remains commingled together. It must be borne in mind that it is not so much the mean temperature of a whole year which affects the possibility of plants growing in any locality, as the fact of what are the extremes of summer and winter temperature."*

This is precisely the explanation given by the commingling of subtropical and arctic floras and faunas of deposits belonging to the Glacial epoch. The causation in the two cases was in fact the same in principle, differing only in the conditions under which it operated. In the case of the Glacial epoch the cold periods were intensely severe and the warm periods but moderately hot; whereas in regard to the Tertiary cold periods they were but moderately cool, and the warm periods exceedingly hot.

Mr. Wallace, who refers to Mr. Gardner's views approvingly, says:—"In the case of marine faunas it is more difficult to judge, but the numerous changes in the fossil remains from bed to bed, only a few feet and sometimes a few inches apart, may be sometimes due to change of climate; and when it is recognized that such changes have probably occurred at all geological epochs, and their effects are systematically searched for, many peculiarities in the distribution of organisms through the different members of one deposit may be traced to this cause."†

To prevent having thus to admit the existence of alternate warmer and colder periods during Tertiary times, Mr. Searles V. Wood, Jun., proposed another theory, which, stated in his own words, is the following:—

"The remains upon which the determination of this flora have been based are drifted, and not those of a bed *in situ* like the coal seams, and the whole of the Hampshire Eocene is connected with

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* Geological Magazine, 1877, p. 25.

† Island Life, p. 197.

the delta of a great river which persisted throughout the accumulation of the various beds, which aggregate to upwards of 2000 feet in thickness. This river evidently flowed from the west through a district of which the low ground had a tropical climate; but like some tropical rivers of the present day, such as the Brahmaputra, the Megna, the Ganges, etc., it was probably fed by tributaries flowing from a mountain-region supporting zones of vegetation of all kinds from the tropical to the Arctic, if during the Eocene period vegetation such as the present Arctic had come into existence, of which we have as yet no evidence. Torrential floods may have swept the remains of vegetation from the temperate zones of this region into tributaries that conveyed it into the main river before it was decayed or water-logged, where it became intermingled with the remains of vegetation which grew in the tropical low ground skirting the main stream, so that both sank together into the same mud and silt."*

The elevated mountain regions from which he supposes these temparate forms were derived he thinks might have been Mull, 400 miles N.N.W., and Wales 200 miles N.W. Mr. Gardner, however, showed most conclusively that Mr. Wood's theory was based on imperfect acquaintance with the conditions of the problem. The following is Mr. Gardner's reply:—

"The leaves have never been drifted from afar; they are often still adhering to the twigs. The leaves are flat and perfect, rarely even rolled and crumpled, as dry leaves may be, if falling on a muddy surface; still more rarely have they fallen edgeways and been imbedded vertically. They are, moreover, not variously mixed, as they should be if they had been carried for any distance, but are found in local groups of species. For example, all the leaves of *Castanea* have been found in one clay patch, with *Iriartea* and *Gleichenia*; none of these have been found elsewhere. A trilobed leaf is peculiar to Studland; the Alum Bay *Aralia*, the peculiar form of *Proteaceæ*, the great *Ficus*, and other leaves occur at Alum Bay only. Each little patch at Bournemouth is characterized by its own peculiar leaves. Such a distribution can result only from the proximity of the trees from which the leaves have fallen. The forms of most temperate asepct are best preserved, so that to be logically applied, the Drift theory requires the palms, etc., to have been drifted upwards. To suppose that most delicate leaves could have been brought by torrents 400 miles from Mull or 200 miles from Wales, and spread out horizontally in thousands, without crease or crumple, on the coast of Hampshire, may be a feasible theory to Mr. Searles V. Wood, Jr., but will not recommend itself to the majority of thinkers." †

Were there Glacial Epochs during the Tertiary Age?—Many geologists, especially amongst those who are opposed to the theory of recurring glacial epochs, answer this question emphatically in the negative. This belief as to the non-existence of glacial conditions during the Tertiary period is, of course, based wholly on negative evidence; and this negative evidence though strong is by no means perfectly conclusive, and certainly not worthy of the weight which has been placed upon it. In Chap. xvii of 'Climate and Time,' I have endeavored to show that although much has been written on the imperfection of geological records, yet the imperfection of those records in regard to the past glacial epochs has not received the attention which it really deserves.

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* Geological Magazine, 1877, p. 96. † Geological Magazine, 1877, p. 138.

It must be borne in mind, however, that it does not follow from the Physical Theory of Secular changes of Climate, that because the eccentricity may have been high at some particular period there must necessarily have been a glacial epoch. The erroneous nature of this misapprehension of the theory has already been shown at considerable length.* Eccentricity can produce glaciation only through means of physical agencies, and for the operation of these agencies, a certain geographical condition of things is absolutely necessary. We know with certainty that during the Tertiary period the eccentricity was at times exceptionally high, as, for example, 2,500,000 and 850,000 years ago; but whether a glacial epoch occurred at these periods depended, of course, upon whether or not necessary geographical conditions then obtained. Supposing the necessary geographical conditions for glaciation did exist at the two periods in question, still if these conditions differed very much from those which now obtain, the glacial state of things then produced would certainly differ from that of the last glacial epoch. This is obvious, for the same physical agencies acting under very different conditions would not produce the same effects. Under almost any geographical condition of things eccentricity would produce marked effects, but the effects produced might not amount to glaciation. In the Tertiary age, during high eccentricity, the effects resulting might possibly have been as well marked as they were during the Glacial epoch; but these effects must have differed very much from those produced at that epoch. We have seen that, owing to that peculiar geographical condition of things existing during the Tertiary period, the physical agents brought into operation by a high state of eccentricity would have a much greater influence in *raising* the temperature of the northern hemisphere, when the winters occurred in perihelion, than they would have in *lowering* the temperature of that hemisphere when the winters were in aphelion. At the periods 2,500,000 and 850,000 years ago, for example, those physical agents would no doubt produce quite a tropical condition of climate in high northern latitudes when the winters were in perihelion, while it is quite probable they may not have been able to produce glaciation when the winters were in aphelion. It is more than likely that the tropical nature of the climate during portions of the Tertiary period was due not so much to that peculiar distribution of land and water existing then, as it was to the fact that this peculiar distribution enabled the physical agents in operation during a high state of eccentricity to impel a vastly greater amount of warm intertropical water into the temperate and Arctic seas than they could have done under the present geographical condition of things.

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* Phil. Mag., February, 1884; American Journal of Science, February, 1884.

Those very same geographical conditions enabling the physical agents to raise the temperature exceptionally high during the warm periods would, on the other hand, prevent them from being able to lower the temperature exceptionally low during the alternate cold periods. Nevertheless, I think it probable that as the two periods referred to, when the eccentricity was much greater than it was during the Glacial epoch, the temperature would be lowered to an extent that would produce glaciation, although the glaciation might not perhaps approach in severity to anything like that of the Glacial epoch. The negative evidence which has been adduced against the existence of such glacial conditions during the Tertiary period is certainly far from being conclusive.

The opinion is concurred in by Mr. Wallace that the Table of Eccentricity for the past three million years, given in 'Climate and Time,' probably includes the greater part, if not the whole, of the Tertiary period. He states that during the 2,400,000 years preceding the last glacial epoch there were, according to the table, no fewer than sixteen separate epochs when the eccentricity reached or exceeded twice its present amount. But it does not follow, according to the Physical Theory, that there ought, on that account, to have been sixteen epochs of more or less glaciation. Whether such ought to have been the case or not would depend on whether or not the geographical conditions were the same during these epochs as they were at the Glacial epoch; a thing regarding which the theory is not responsible. The question is not were there sixteen glacial epochs during the Tertiary period, but were there any? Even granted that those channels assumed by Mr. Wallace did exist, they would not, I feel assured, wholly prevent glaciation taking place at the two periods to which reference has been made, although the glaciation might not be severe.

In support of the opinion that there is no evidence of glaciation during the Tertiary period, Mr. Wallace quotes the views of Mr. Searles V. Wood, Jr., on the subject. Mr. Wood states that the Eocene formation is complete in England, and is exposed in continuous section along the north coast of the Isle of Wight and along the northern coast of Kent from its base to the Lower Bagshot Sand. It has, he says, been intersected by cuttings in all directions and at all horizons, but has not yielded a trace of any thing indicating a cold and glacial condition of things. The same, he adds, holds true of the strata in France and Belgium. Further, "the Oligocene of Northern Germany and Belgium, and the Miocene of those countries and of France, have also afforded a rich molluscan fauna, which, like that of the Eocene, has as yet presented no indication of the intrusion of any thing to interfere with its uniformly subtropical character."

In reply to all this it may be stated that the simple absence of any trace of glaciation in the Tertiary deposits of the South of England certainly cannot be regarded as conclusive against the existence of an epoch of glaciation during that period. Not many years ago geologists denied that there was any evidence to be found of glaciation in the South of England, and at the present time there are hundreds of geologists who will not admit that that part was ever overridden by land-ice. If it is so difficult to find in that quarter evidence of the last glacial epoch, severe as that glacial epoch was, we need not wonder that no trace of glaciation so remote as that of the Eocene period is now to be seen. Besides all this, there is in the South of England the land-surface on which the glaciation, if any, took place, whereas not a vestige of the old land-surfaces of the Eocene period now remains. It therefore seems to me that the mere fact of nothing as yet having been found in the Tertiary deposits of the South of England, indicating one or more cold periods, is no proof that there may not possibly have been such periods, and even of considerable severity. The same remarks hold equally true in regard to the deposits on the continent referred to by Mr. Wood.

It will be urged in reply that there is one kind of evidence which ought to be found, as it could not possibly have been obliterated by the destruction of the Tertiary land-surfaces. That is the presence of erratic blocks and foreign rock-fragments imbedded in the strata. Mr. Wallace states that in the many thousand feet in thickness of alternate clays, sands, marls, shales, and limestones no irregular blocks of foreign material or bowlders characteristic of glacial conditions are to be found. The same, he says, holds equally true of the extensive Tertiary deposits of temperate North America.

If it be really the case that the Tertiary beds are wholly without bowlders or fragments of foreign material, then this certainly may be regarded as proof that no real glacial epoch could have occurred during that period. But has it been satisfactorily ascertained that those beds are wholly devoid of such materials? Those beds, I presume, have been searched by geologists for their fossil contents rather than for stratigraphical evidence of glacial epochs. It is remarkable how long the evidence of glaciation sometimes remains unobserved when no special attention is devoted to the matter. As examples of this we know with certainty that the Orkney and Shetland Islands were during the Glacial epoch overridden by land-ice; and yet geologists who had often visited these islands declared that they bore no marks of glaciation. So recently as 1875 the low grounds of Northern Germany were believed to be without glacial striæ; yet when German geologists began to turn their attention specially to the subject, they found not only evidence of glaciation, but indisputable proof that during the Glacial epoch the great Scandinavian ice-sheet had advanced over the country no fewer than three separate times down to the latitude of Berlin. I have myself seen the striated summit of a mountain on which geologists had been treading for years without observing the ice-markings under their feet. The reasons why these markings so long escaped detection is doubtless due to the fact that they were on a spot which no geologist supposed that land-ice could have reached. For this very same reason the fact remained so long unobserved, that the low-lying ground of Caithness had been glaciated by land-ice from Scandinavia, filling the entire Baltic and the North Sea. Many similar cases might be adduced where the marks of glaciation remained long unobserved, either because no special search had been made for them or because they were under conditions in which they were not expected to be found. It is very probable that when the Tertiary deposits are carefully examined, with the special object of ascertaining whether or not they contain evidence of glaciation, geologists may be led to a different conclusion regarding the supposed uniformly warm character of the climate of that period. They may possibly find that, after all, the Tertiary beds do contain bowlders and foreign material, indicating the existence of glacial conditions during that period.

Considerable importance has been attached to the statement of Professor Nordenskjöld that he failed to observe in the stratified deposits of Greenland and Spitzbergen any evidence whatever of former glaciation in those regions. "We have never seen," says he, "in Spitzbergen nor in Greenland, in these sections often many miles in length, and including one may say all formations from the Silurian to the Tertiary, any bowlders even as large as a child's head. There is not the smallest probability that strata of any considerable extent, containing bowlders, are to be found in the polar tracts previous to the middle of the Tertiary period. Both an examination of the geognostic condition, and an investigation of the fossil flora and fauna of the polar lands, show no signs of a glacial era having existed in those parts before the termination of the Miocene period."* That Prof. Nordenskjöld may not have seen in those strata bowlders larger than a child's head may be perfectly true, but that there actually are none is a thing utterly incredible. Still more incredible, however, is the conclusion which he draws from this absence of bowlders, viz: that from the Silurian down to the termination of the Miocene period no glacial condition of things existed either in Greenland or in Spitzbergen. Both these places are at present in a state of glaciation, and were it not, as we have seen, for the enormous quantity of heat which is being transferred from the equatorial regions by the Gulf-stream, not only Greenland and Spitzbergen, but the whole of the Arctic regions would be far more under ice than they are. A glacial state of things is the normal condition of polar regions, and if at any time, as during the Tertiary age, the Arctic regions were free from snow and ice, it could only be in consequence of some peculiar distribution of land and water and other exceptional conditions. That this peculiar combination of circumstances should have existed during the whole of that immense lapse of time between the Silurian and the close of the Tertiary period is certainly improbable in the highest degree. In short, that Greenland during the whole of that time should have been free from snow and ice is as improbable, although perhaps not so physically impossible, as that the interior of that continent should at the present day be free from ice and covered with luxuriant vegetation. Perhaps the same skill and indomitable perseverance which proved the one conclusion to be erroneous may yet one day prove the other to be also equally erroneous.

Professor Nordenskjöld does not appear to believe in alternations of climate even in temperate regions, for he says "from palæontological science no support can be obtained for the assumption of a periodical alternation of warm and cold climates on the surface of the earth."

Evidence of Glaciation during the Tertiary period.—Evidence of glaciation during the Miocene period is, I think, afforded by the well-known conglomerates and erratics near Turin, first described by M. Gastaldi. Beds of Miocene sandstone and conglomerate, with an intercalated deposit containing large angular blocks of greenstone and limestone, have been found. Some of these blocks are of immense size. Many of the stones in the deposit are polished and striated in a manner similar to those found in the Bowlder-clay of this country. It has been shown by Gastaldi that these blocks have all been derived from the outer ridge of the Alps on the Italian side, namely from the range extending from Ivrea to the Lago Maggiore, and, consequently, they must have traveled from twenty to eighty miles. So abundant are these large blocks that extensive quarries have been opened in the hills for the sake of procuring them. The stratification of the beds amongst which the blocks occur sufficiently indicate aqueous action and the former presence of the sea. That glaciers from the southern Alps actually reached to the sea, and sent adrift their icebergs over what are now the sunny plains of Northern Italy, is proof that during that cold period the climate must have been very severe. One remarkable circumstance, indicating not only the glacial condition of the bed in which the blocks occur, but also that this glaciation was the result of eccentricity, is the fact that the bed is wholly destitute of organic remains while they are found abundantly both in the underlying and overlying beds.

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* Geological Magazine, 1875, p. 531.

Evidence of glaciation during the Eocene period, as is also well known, is found in the "*flysch*" of Switzerland. On the north side of the Alps, from Switzerland to Vienna, and also near Genoa, there is a sandstone a few thousand feet in thickness, containing enormous blocks of Oolitic limestone and granite. Many of these blocks are upwards of 10 feet in length, and one at Haelkeren, near the Lake of Thun, is 105 feet long, 90 feet broad, and 45 feet in thickness. The block is of a granite of a peculiar kind which cannot be matched anywhere in the Alps. Similar blocks are found in beds of the same age in the Appenines and in the Carpathians. The glacial origin of this deposit is further evinced by the fact that it is wholly destitute of organic remains. One circumstance, which indicates that this glaciation was due to eccentricity, is the fact that the strata most nearly associated with the "*flysch*" are rich in Echinoderms of the *Spatangus* family, which have a decided tropical aspect. This is what we ought, of course, *à priori*, to expect if the glaciation was the result of eccentricity, for the more severe a cold period of a glacial epoch is, the warmer will be the periods which immediately precede and succeed.

Some writers endeavor to account for those glacial phenomena, without any reference to the influence of high eccentricity, by the assumption that the Alps were much more elevated during the Tertiary period than they are at the present day. If we, however, adopt this explanation, we shall have to assume that the Alps were suddenly elevated at the time when the bed containing the erratics began to be deposited, and that they were as suddenly lowered when the disposition of the bed came to a close—a conclusion certainly very improbable. Had the lowering of the Alps been effected by the slow processes of denudation, it must have taken a long course of ages to have lowered them to the extent of bringing the glacial state to a close. In this case there ought to be a succession of beds indicating the long continuance of cold conditions. Instead of this, however, we have a glacial bed immediately preceded and succeeded by beds indicating an almost tropical condition of climate. When we take this circumstance into consideration, along with the evidence adduced by Mr. J. S. Gardner as to the alternations of warmer and colder conditions in the South of England and other parts of Europe during the Eocene period, the conviction is forced upon us that a high state of eccentricity is the most rational explanation of these curious phenomena.

The greater elevation of the Alps would undoubtedly intensify the glacial condition of things, but it would not originate it. The elevated character of the Alps, for example, was no doubt the reason why the plains of Switzerland, during the last glacial epoch, were so much more buried under ice than other parts of Southern Europe; but their elevation was not that which brought about the glaciation, for those plains were free from ice both before and after the glacial epoch, though the Alps were no doubt as high as they were during the ice-period.

If we adopt the theory that these glacial conditions were due to eccentricity, then we have, as I endeavored to show many years ago,* a clue to the probable absolute date of the Middle-Eocene and the Upper-Miocene periods. There were, as we have seen, two epochs during the Tertiary period when the eccentricity was exceptionally high, viz: 2,500,000 years ago and 850,000, years ago. The former might probably be the date of the "*flysch*" of the Eocene formation, and the latter the date of the period when the Miocene erratics were deposited in the icy sea near Turin.

Some geologists have maintained that the climatic conditions of the Tertiary period are utterly hostile to the Physical Theory of Secular changes of Climate. The very reverse, however, is the case; for, as we have seen, several of the facts of Tertiary climate can be explained on no other principle than that of the theory.

I shall next consider the facts bearing on Arctic Interglacial periods.

* Phil. Mag., November, 1868; 'Climate and Time,' chap. xxi.

Art. XXII.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, No.* 11; by A. E. Verrill. *Brief Contributions to Zoology from the Museum of Yale College.* No. LVII.

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Work of the Steamer Albatross in 1884.

The deep-sea Anthozoa obtained last season were numerous and interesting, but there were among them only a few entirely new forms, for most of them had been dredged by the Albatross in 1883, or by the Blake in 1880. The most remarkable new species, of which one imperfect specimen had been taken in 1883, but not described, represents a new genus of Pennatulidæ. I have named this *Benthoptillum sertum.*[*] This, which was taken in 991 to 1073 fathoms, is a remarkable exception

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[*] *Benthoptillum*, gen. nov. Large, rather stout, Pennatula-shaped sea-pens, with very long and large polyps, arranged in several large, oblique, lateral clusters, arising from short, swollen, wing-like elevations, consisting of the united bases of the polyps and not supported by spines and spicules. The polyps throughout the greater part of their length are free, without calicles, and destitute of spicules. The tentacles are very long and plumose, without spicules. The zöoids are minute, very abundant, covering the ventral, lateral and dorsal surfaces of the rachis, and extending in rows on the bases of the polyps, leaving only a narrow, naked, median, ventral band. The axis extends through the whole length and is quadrangular, with concave sides. The stalk is rather short, with a terminal bulb and a slight enlargement near the upper end. The eggs are contained in the bases of the polyps within the lateral pinnæ.

Benthoptillum sertum, sp. nov. The pinnæ in the largest specimen are eight on each side and stand nearly opposite; those along the middle of the rachis largest, the others diminishing very gradually towards the stalk, the lowest pair being but slightly developed, very little prominent, consisting of only a few polyps which are united only very close to the base. The four middle pairs of pinnæ are very broad and swollen at the base, considerably elevated, and give rise to a very large number of long and large flexible polyps, which are arranged in numerous crowded rows, so as to form a large, compact cluster, the larger clusters having about forty polyps. The opposite clusters approach so closely on the dorsal side as to blend more or less together. The outermost row on the ventral side contains about twelve polyps the bases of which are swollen and distinguishable nearly to the base of the pinnæ. They form an oblique row in which the lower successively overlaps the one above it. The zöoids appear as minute granules, which cover the entire surface of the rachis, except the narrow, median, ventral band, and form groups between the bases of the polyps on the dorsal side, running up between their bases on the ventral side. The successive pairs of pinnæ are separated by considerable intervals on the ventral side, but nearly run together on the dorsal side. The axis is rather stout and has a deep groove on the ventral side.

In life the general color was blood-red. In alcohol the stalk and rachis are yellowish white with a tinge of orange on the sides; the polyps are translucent grayish white or dull purplish with the tentacles chestnut-brown to deep reddish brown, the stomach dull purplish color, showing through the walls.

Total length of the larger specimen, 300^{mm}; length of the naked stalk, 93^{mm}; diameter of the stalk, 5^{mm}; diameter of rachis, 6^{mm}; total breadth from tip to tip of expanded polyps, 140^{mm}; breadth across largest pinnæ, 22^{mm}; length of to the generalization made by Professor Kölliker, in his report on the Challenger Pennatulacea, p. 38, that only the simpler forms of Pennatulacea occur in deep water, for our new genus is a very highly organized and specialized form, of large size, with complex lateral groups of very large polyps. But our two species of *Pennatula* (*P. aculeata* and *P. borealis*) both range downward to 1255 fathoms, and the generalization referred to will probably be found to rest on very insufficient evidence. A small species of *Stylatula* was also dredged in 444 fathoms, but it has not yet been identified. The genus was new to our Atlantic coast.

Three specimens of a very handsome European cup-coral (*Desmophyllum crista-galli*), never before observed on the American coast, were taken this year in 1054 to 1060 fathoms. Two of these were of very large size. Curiously enough another species of this genus was obtained at about the same time by one of the Gloucester fishing vessels off Nova Scotia and was sent to the Fish Commission at Wood's Holl by Capt. J. W. Collins. This is a very large and handsome species (*D. nobile* V.),[*] evidently entirely new. It somewhat resembles

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free portion of polyps to tip of tentacles, 58^{mm}; length of tentacles, 15^{mm}; diameter of polyps at stomach, 3^{mm}.

Station 2205, in 1073 fathoms, N. lat. 39° 35′, W. long. 71° 18′ 45″, one large specimen, and station 2210, in 991 fathoms, N. lat.? 39° 37′ 45″, W. long.? 71° 18′ 45″; station 2115, in 843 fathoms (No. 6729), 1883.

[*] *Desmophyllum nobile* V., sp. nov. Corallum solid, vase-shaped, arising from a broadly expanded base, a short distance above it contracts somewhat, and then expands to the summit. The walls are pure white, smooth, polished, somewhat lustrous, without any appearance of granulation. The calicle is broad, deep, nearly circular, and apparently thick at the edges, owing to the peculiar lateral thickening of the smallest septa. There is no visible columella. The septa are forty-eight, in four regular cycles. The twelve primary septa are very much higher and broader than the others, with the inner edges nearly perpendicular and converging so near the center as to leave but a very narrow central pit. Toward the summit the inner edge is obliquely truncated or slightly concave, while the extreme summit is broadly rounded and very prominent. The exterior margin is broadly rounded, usually flexuous or irregularly lobed or notched, and projects far beyond the border of the calicle in the form of very prominent, crest-like costæ, which extend a short distance below the margin of the calicle and then are suddenly narrowed, fading out entirely before reaching the narrowest part of the pedicle; they are rather thin at the inner and superior edges but are considerably thickened toward the wall and in their exterior portions; their surfaces within the calicle are coarsely granulated, but on their upper and outer portions the surfaces are glazed and polished. The secondary septa are similar in form and structure to the primary ones, but are much smaller and thinner, their inner edges do not extend so far inward and the summit does not rise nearly so high, but the exterior or costal portion is nearly as prominent and thick as the primaries, but is more suddenly narrowed and does not extend so far down the side of the coral. The septa of the third cycle are still narrower and lower, with the inner portions quite thin, while the portion next the margin of the calicle is very conspicuously thickened by swollen deposits which connect them laterally with the adjacent septa; their exterior portion is scarcely prominent, not forming distinct costæ.

Total height to the summit of the highest septa, 56^{mm}; height to margin of

D. ingens Moseley, from the Straits of Magellan, but has only forty-eight septa, which are remarkably thickened and very unequal, while the exterior is smooth with an ivory-like polish. An apparently undescribed species of *Paracyathus* occurred in 1054 fathoms, but it has not been fully studied.

A peculiar new species of *Epizoanthus* (*E. abyssorum* V.) was taken several times in 1555 to 2033 fathoms. It usually formed the covering of a hermit-crab (*Parapagurus pilosimanus*). The polyps are rather large, usually five or six, divergent, clavate in contraction, and closely covered with a grayish coating of small foraminifera. The closed summit has twenty-four convergent radii. The polyps in alcohol are 10 to 15^{mm} long, 9 to 11^{mm} broad.

In addition to the starfishes referred to in my last article, there is, from 1098 and 1451 fathoms, a very interesting new species belonging to the peculiar deep-sea genus, *Hymenaster*,[*] of which many species were dredged by the Challenger in various parts of the world. An additional new species of *Archaster*[†] has also been recognized. It was taken in 858 fathoms, in 1883, and in 368 fathoms, in 1881.

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calicle, 42^{mm}; diameter of the pedicle in the middle where narrowest, 21^{mm}; longest diameter of the calicle, 34^{mm}; shorter diameter, 31^{mm}; breadth of the primary septa, 20^{mm}; height above margin of calicle, 14^{mm}; breadth of the exterior or costal portion, 7^{mm}; breadth of secondary septa, 16^{mm}; height above margin of calicle, 8^{mm}; breadth of tertiary septa, 6^{mm}; height above margin of calicle, 4 to 5^{mm}.

The only specimen known was taken July 15th, 1884, on the "Stone Fence," on Banquereau, N. S., in about 300 fathoms (approximate position N. lat. 44° 28′, W. long. 57° 13′) by Michael Campbell, of Gloucester, Mass.

[*] *Hymenaster modestus*, sp. nov. Body small, pentagonal, with concave borders, rays short, broad, each adambulacral plate bears three very slender, acute spines; two are at the inner edge, and of these the distal is much shorter than the other; the third is external to the others, more erect and slightly larger. The ventral radial spines are very slender, not crowded, 16 to 18 on each side; the longest ones are the 5th and 6th; these and those beyond reach the margin, which is scolloped between them. The dorsal paxillæ project through the membrane as small spinules; they are pretty uniformly distributed and there are no defined radial areas. Color pale buff above, pink beneath. Greater radius, 10^{mm}; lesser radius, 7^{mm}. Stations 2052 and 2096, 1098 and 1451 fathoms.

[†] *Archaster sepitus*, sp. nov. This species is more nearly related to *A. tenuispinus* than to any of our other species. It agrees with the latter in form, in having a prominent, acute central spine on the dorsal paxillæ, and in the general character of the spinulation, in the projecting adambulacral plates, and apparently in the presence of special pores at the base of the arms. Its disk is smaller, its marginal plates more prominent and convex or swollen, its marginal spines much larger and more regular, and the spinules on the marginal plates much longer and sharper, while the ventral interbrachial areas are much smaller.

The marginal spines are longer than the breadth of the plates, and the spinules on the plates divergent and sharp. The lower plates are as prominent as the upper and bear similar spinules, with a median spine near the upper end, like those of the upper row, and sometimes with a lower one of the same form; these plates abut directly against the adambulacral plates. The latter project strongly into the groove and each bears a group of eight to ten slender divergent spines, those in the middle longest, with a larger, outer, erect central spine. Ventral interbrachial

Another large and handsome new star-fish, which was taken in several localities, in 843 to 1395 fathoms, both this year and last, is a species of *Solaster* (*S. abyssicola* V.)* somewhat resembling *S. endeca* and *S. Earllii* in general appearance, but differing from both in the arrangement of the spines, especially beneath. The color is bright orange in life. It becomes over a foot in diameter, with a broad disk, and usually eight or nine rays.

Among the deep sea Ophiurans no genus is more common and widely diffused than *Ophiacantha*. Of this genus we have taken, during the two past seasons, eleven or twelve species, besides one each of the closely allied genera *Ophiolebes* and *Ophiomitra*. Most of these forms live clinging closely to the branches of gorgonians. All the species that I have tested are brilliantly phosphorescent.

The most abundant are *O. bidentata*, *O. millespina* V. and *O. abyssicola* G. O. Sars; these three, which are very similar in appearance, are closely allied forms, and the last two may even prove to be identical. But some of the others, like *O. anomala*, with six arms, and *O. spectabilis*, with short, stout, granulose arm-spines and slender, tapering, acute disk spines, are very distinct forms. The same is true of three new species: *O. crassidens*,† having strong, acute disk-spines and remarkably

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plates few, each with a sharp central spine, surrounded by an irregular group of small spinules. Greater radius, 34^{mm}; lesser, 9^{mm}; breadth of rays at base, 9^{mm}. This example has 16 marginal plates in each row. Station 2072, in 858 fathoms, four specimens; station 994, in 368 fathoms, one young.

* *Solaster abyssicola* V., sp. nov. Disk broad. Rays usually eight or nine, varying to seven and ten. Abactinal side covered with rather small, not very close, rounded paxillæ, bearing small and short spinules. The branchial papulæ are large and numerous, thickly scattered on the disk and base of arms. Marginal plates prominent, bearing a transverse group of small, rough spinules, in two or three rows. Inter-brachial ventral areas of moderate size, covered with rounded paxillæ, similar to those of the back, arranged in regular rows, and bearing a divergent group of five to eight small, rough spinules. The adambulacral plates bear an outer transverse row of five to seven rather short, moderately thick spines, united at base and covered by a thick skin; and an inner group of three or four, nearly equal and rather short spines, united together by a web for about half their length.

† *Ophiacantha crassidens*, sp. nov. Arms five, rather short. Disk rounded, covered with rather small, tapered, subacute, slightly roughened spines, which arise from well developed, crowded plates, only partly concealed by a thin skin; radial shields nearly concealed. Arm-spines at base of arms, seven, hollow, minutely roughened or granulose, short, brownish, opaque, the five lower ones subequal, unusually short and blunt, becoming very short and acute distally; the next two rather longer and tapered; the uppermost smaller and more slender, acute, those of opposite sides well separated. Ventral arm-plates prominent, especially distally, the outer end rounded. Tentacle-scale large, stout, ovate, distally becoming short and blunt. Ventral side of disk distinctly scaled, with few spines. Mouth-shields triangular with acute inner angle, concave sides and convex outer margin, granulous. Teeth remarkably large, broad and thick, longitudinally roughened; mouth-papillæ few, three or four on each side, very stout, flattened, roughened and brown, like the teeth, which the

thick, stout teeth and mouth-papillæ; *O. enopla*,* with numerous long and very slender arm-spines, short obtuse stumps on the disk, and an unusually large number of slender acute mouth-papillæ, much crowded at the outer corners; and *O. granulifera*,† which has the disk closely covered with small granules and has unusually wide and short ventral arm-plates. Another large species,‡ of which several were found clinging to the arms of *Brisinga spinulosa* V., also appears to be new.

The *Ophiolebes Acanellæ* V., referred to above, lives clinging to the branches of *Gorgonians*, dredged off Nova Scotia, and closely resembles some species of *Ophiacantha*, but has fewer and shorter spines and its disk is covered with short, rough, round-topped stumps or large granules. *Amphilepis Norvegica* was taken several times in 1395 to 1555 fathoms.

The *Ophiomitra* is a new species § of large size, allied to

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inner ones resemble in size and form, the others successively smaller. Color dull brown, the spines and teeth darker.

Diameter of disk, 13^{mm}; length of arms about 40^{mm}; largest spines, $2·5^{mm}$. Stat. 2115, in 843 fathoms, N. lat. 35° 49′ 30″, W. long. 74° 34′ 45″, 1 specimen, No. 9370.

* *Ophiacantha enopla*, sp. nov. Disk rounded, rather smaller, arms five, rather long, side plates prominent, with long, slender, glassy, acute, minutely thorny spines, of which there are eight in the largest clusters near the base of the arms, the three upper ones decidedly longer and smoother than the five lower ones; the clusters do not approach very nearly on the dorsal side, at the base of the arms. Dorsal plates rhombic, longer than broad. The disk is thickly covered with small, short, stout, blunt stumps, looking like granules, and terminated by a group of 5 to 8 small, rough, irregular spinules; beneath they become rounded granules. Mouth-shields small, transversely elongated and subrhombic, the outer angle slight, scarcely extending on the interbrachial area. Tentacle-scale minute; mouth-papillæ rather long, acute, very numerous, 7 to 9 on each side of each jaw, crowdedly clustered near the outer end of the mouth-slits, where there are five or six standing nearly erect on each side, while two or three more horizontal ones stand nearer the inner end. Yellowish white in alcohol; orange while living.

Diameter of disk. 12^{mm}: length of arms, 65^{mm}; longest spines, 4^{mm}.

Stations 1123, 1124, 2046, in 351 to 640 fathoms.

† *O. granulifera* V., sp. nov. Disk finely granulated, with slightly raised radial ridges, showing the naked tips of the radial shields. Arms rather broad, arm-spines on basal joints, 8 or 9, a little rough; the upper ones long and slender, the rows not approximating above; tentacle-scale small, lanceolate, except the basal ones Ventral plates short, transversely oblong on 2d to 7th joints, becoming trapezoidal farther out. Radial shield strongly 4-lobed, small. Mouth-papillæ all spiniform, 3 or 4 on each side of a jaw.

Diameter of disk 9 to 11^{mm}. Off Nova Scotia, 101 to 200 fathoms.

‡ *Ophiacantha aculeata*, sp. nov. A large orange species with long tapering arms, and very long, slender, slightly rough spines, 8 or 9 on each side, near the disk, the rows nearly meeting above. The disk is rounded and full, with the ends of radial shields not exposed; surface evenly covered with very slender rough spinules, terminated by several sharp points. Jaws wider and more obtuse than usual; the mouth-papillæ are rather slender, all acute, usually 4 or 5 on each side of a jaw. Tentacle scale lanceolate acute, not very large. Mouth-shields rather small, convex on outer edge, obtusely angled on the inner.

Stations 2034 and 2105, in 1346 and 1395 fathoms.

§ *Ophiomitra spinea* V., sp. nov. Radial-shields broad-ovate, notched at outer end, separated by a triangular wedge of scales; small unequal scales cover the disk, and bear small conical and rounded granules. Arm-spines 8 or 9 at base of

List of Stations occupied by the Albatross in 1884.

Station.	Locality.		Fath.	Bottom.	Temp., F.		Hour.	Date.
	N. Lat.	W. Long.			Bottom.	Surface.		
	Off Chesapeake Bay.							July
2170	37°57′00″	73°53′30″	155	gy. s	--	71°	11.40 A. M.	20
2171	37 59 30	73 48 40	444	gn. M., s., cns.	39°	75	1.25 P. M.	20
2172	38 01 15	73 44 00	568	"	39	76	3.45 "	20
2173	37 57 00	72 34 00	1600	glb. o.	37	70	6.26 A. M.	21
2174	38 15 00	72 03 00	1594	gy. M.	?	76	2.59 P. M.	21
	Off Martha's Vineyard.							
2175	39 33 00	72 18 30	452	gn. M.	40	68	9.03 A. M.	22
2176	39 22 30	72 21 30	302	bk. M.	41	68	12.34 "	22
2177	39 33 40	72 08 45	87	gn. M., s.	42	68	3.40 P. M.	22
2178	39 29 00	72 05 15	229	"	42	68	5 16 "	22
2179	39 30 10	71 50 00	510	bk. M.	39	67	4.02 A. M.	23
2180	39 25 50	71 49 30	523	"	39	68	6.48 "	23
2181	39 29 00	71 46 00	693	M., fne. s.	39	68	9.42 "	23
2182	39 25 30	71 44 00	861	gn. M.	39	68	12.58 M.	23
								Aug.
2183	39 57 45	70 56 30	195	gn. M., s.	44	68	11.52 A. M.	2
2184	40 00 15	70 55 30	136	"	49	70	1.08 P. M.	2
2185	40 00 45	70 54 15	129	"	51	69	2.12 "	2
2186	39 52 15	70 55 30	353	"	40	69	6.12 "	2
2187	39 49 30	71 10 00	420	gn. M.	40	68	10.44 A. M.	3
2188	39 54 30	71 08 00	235	gn. M., s.	43	70	1.54 P. M.	3
2189	39 49 30	70 26 00	600	gn M.	40	71	4.16 A. M.	4
2190	39 40 00	70 20 15	1180	gn. glb. o.	--	73	10.42 "	4
2191	39 45 30	70 17 00	961	gn. M.	--	73	2.46 P. M.	4
2192	39 46 30	70 14 45	1060	o., c., cns.	39	72	5.45 A. M.	5
2193	39 44 30	70 10 30	1122	gn. M.	38	73	11.04 "	5
2194	39 43 45	70 07 00	1140	bn. o.	38	74	2.54 P. M.	5
2195	39 44 00	70 03 00	1058	gn. M., st.	38	74	6.42 "	5
2196	39 35 00	69 44 00	1230	"	38	74	4.45 A. M.	6
2197	39 56 30	69 43 20	84	s., brk. sh.	52	74	11.24 "	6
2198	39 56 30	69 43 20	84	"	52	74	1.17 P. M.	6
2199	39 57 30	69 41 10	78	gn. s.	--	74	2.03 "	6
2200	39 53 30	69 43 20	148	s., brk. sh.	45	74	4.38 "	6
2201	39 39 45	71 35 15	538	bu. M.	39	66	6.10 A. M.	19
2202	39 38 00	71 39 45	515	gn. M.	39	67	9.23 "	19
2203	?39 34 15	71 45 15	705	gn. M., s.	39	74	12.20 P. M.	19
2204	?39 30 30	71 44 30	728	bu. M.	39	74	4.32 "	19
2205	39 35 00	71 18 45	1073	gy. o.	38	73	4.37 A. M.	20
2206	?39 35 00	71 24 30	1043	gn. M.	38	74	9.16 "	20
2207	39 35 33	71 31 45	1061	"	39	74	1.01 P. M.	20
2208	39 33 00	71 16 15	1178	gn M., st., cns.	38	74	5.02 A. M.	21
2209	39 34 45	71 21 30	1080	glb. o.	39	74	9.42 "	21
2210	?39 37 45	71 18 45	991	"	38	74	1.18 P. M.	21
2211	?39 35 00	71 18 00	1064	gn. M.	38	74	4.45 "	21
2212	?39 59 30	70 30 45	428	"	40	71	4.48 A. M.	22
2213	?39 58 30	70 30 00	384	"	39	71	8.04 "	22
2214	39 57 00	70 32 00	475	"	39	74	11.30 "	22
2215	39 49 15	70 31 45	578	----	--	74	3.13 P. M.	22
2216	39 47 00	70 30 30	963	gn. M.	39	71	5.38 "	22
2217	39 47 20	69 34 15	924	gy. M.	38	73	4.49 A. M.	23
2218	39 46 22	69 29 00	948	"	39	74	10.41 "	23

List of Stations occupied by the Albatross in 1884—*continued.*

Station.	Locality. N. Lat.	Locality. W. Long.	Fath.	Bottom.	Temp., F. Bottom.	Temp., F. Surface.	Hour.	Date.
	Off Martha's Vineyard.							
2219	39°46′22″	69°29′00″	948	gy. M.	39°	74°	1.36 P. M.	Aug. 23
2220	?39 43 30	69 23 00	1054	"	38	74	4.18 "	23
2221	39 05 30	70 44 30	1525	gy. o., bricks.	37	75	9.01 A. M.	Sept. 6
2222	39 03 15	70 50 45	1537	"	37	73	2.20 P. M.	6
	Off Chesapeake Bay.							
2223	37 48 30	69 43 30	2516	glb. o.	36	75	5.07 A. M.	7
2224	36 16 30	68 21 00	2574	"	37	79	8.31 "	8
2225	36 05 30	69 51 45	2512	yl. o.	37	78	5.47 "	9
2226	37 00 00	71 54 00	2021	glb. o., st.	37	80	5.06 "	10
2227	36 55 23	71 55 00	2109	"	37	82	12.24 P. M.	10
2228	37 25 00	73 06 00	1582	bu. M., ons.	37	77	5.[illegible] A. M.	11
2229	?37 38 40	73 16 30	1423	glb. o.	38	75	4.12 P. M.	11
	Off Delaware Bay.							
2230	38 27 00	73 02 00	1168	gy. o., c., ons.	37	75	4.37 A. M.	12
2231	38 29 00	73 09 00	965	"	37	75	9.42 "	12
2232	?38 37 30	73 11 00	243	gn. M.	43	74	2.48 P. M.	12
2233	?38 36 30	76 06 00	630	"	39	73	4.16 "	12
	Off Martha's Vineyard.							
2234	39 09 00	72 03 15	816	gn. M.	39	71	4.30 A. M.	13
2235	39 12 00	72 03 30	707	"	39	72	7.33 "	13
2236	39 11 00	72 08 30	636	"	39	72	9.49 "	13
2237	39 12 17	72 09 30	520	"	39	72	11.42 "	13
2238	39 06 00	72 10 00	904	gy M.	39	72	2.26 P. M.	13
2239	40 38 00	70 29 45	32	gn. M.	--	62	5.05 A. M.	26
2240	40 27 30	70 29 00	44	"	--	61	7.29 "	26
2241	40 21 00	70 29 15	50	"	51	63	9.20 "	26
2242	40 15 30	70 27 00	58	"	51	63	11.33 "	26
2243	40 10 15	70 26 00	63	"	52	64	1.13 P. M.	26
2244	40 05 15	70 23 00	67	gn. M., s.	53	71	3.11 "	26
2245	40 01 15	70 22 00	98	M., bk. s.	51	61	4.50 "	26
2246	39 56 45	70 20 30	122	gn. M.	48	71	6.43 "	26
2247	40 03 00	69 57 00	78	gn. M., s.	52	70	4.57 A. M.	27
2248	40 07 00	69 57 00	67	M., s., brk. sh.	52	70	6.50 "	27
2249	40 11 00	69 52 00	53	M., fne. s.	51	70	8.24 "	27
2250	40 17 15	69 51 45	47	"	51	68	10.04 "	27
2251	40 22 17	69 51 30	43	"	51	65	12.02 P. M.	27
2252	40 28 00	69 51 00	38	"	50	63	1.46 "	27
2253	40 34 30	69 50 45	32	s., bk. spk.	53	61	3.11 "	27
2254	40 40 30	69 50 30	25	"	54	61	4.39 "	27
2255	40 46 80	69 50 15	18	"	56	60	6.10 "	27
2256	40 38 30	69 29 00	30	yl. s.	53	61	5.42 A. M.	28
2257	40 32 30	69 29 00	33	s., bk. spk.	52	61	7.17 "	28
2258	40 26 00	69 29 00	36	"	51	61	8.34 "	28
2259	40 19 30	69 29 10	41	"	50	61	9.56 "	28
2260	40 13 15	69 29 15	46	gy. s.	50	65	11.13 "	28
2261	40 04 00	69 29 30	58	s., bk. spk.	54	66	12 52 P. M.	28
2262	39 54 45	69 29 45	250	gn. M., s.	42	67	2,51 "	28

List of Stations occupied by the Albatross in 1884*—continued.*

Station.	Locality.		Fath.	Bottom.	Temp., F.		Hour.	Date.
					Bottom.	Surface.		
	Off Chesapeake Bay.							
	N. Lat.	W. Long.						Oct.
2263	37°08′00″	74°33′00″	430	gn. M.	47°	66°	1.06 P. M.	18
2264	37 07 50	74 34 20	167	gy. s.	58	66	2.37 “	18
2265	37 07 40	74 35 40	70	gn. M., G., sh.	63	67	3.47 “	18
	Off Cape Hatteras.							
2266	35 07 00	75 08 30	111	fne. s.	73	78	6.00 A. M.	19
2267	35 08 50	75 07 20	68	gy. M.	71	79	6.39 “	19
2268	35 10 40	75 06 10	68	“	77	79	7.43 “	19
2269	35 12 30	75 05 00	48	crs. G.	76	75	8.46 “	19
2270	35 14 15	75 07 00	32	fne. gy. s.	--	75	9.40 “	19
2271	35 16 00	75 09 00	26	----	--	75	10.45 “	19
2272	35 20 10	75 14 00	15	s., bk. spk.	--	75	11.57 “	19
2273	35 20 30	75 17 30	17	“	72	72	12.45 P. M.	19
2274	35 20 35	75 18 05	16	“	--	71	1.22 “	19
2275	35 20 40	75 18 40	16	“	--	71	1.43 “	19
2276	35 20 45	75 19 15	16	“	--	71	2.08 “	19
2277	35 20 50	75 19 50	16	“	--	71	2.21 “	19
2278	35 20 55	75 20 20	16	“	--	71	2.45 “	19
2279	35 20 55	75 20 55	16	“	--	71	3.36 “	19
2280	35 21 00	75 21 30	16	“	--	70	4.15 “	19
2281	35 21 05	75 22 05	16	“	--	70	4.35 “	19
2282	35 21 10	75 22 40	14	bk. s.	--	70	5.13 “	19
2283	35 21 15	75 23 15	14	gy. s.	--	70	5.41 “	19
2284	35 21 20	75 23 50	13	crs. gy. s.	--	70	6.09 “	19
2285	35 21 25	75 24 25	13	“	--	70	6.40 “	19
2286	35 21 30	75 25 00	11	“	--	70	7.13 “	19
2287	35 22 30	75 26 00	7	“	--	69	6.15 A. M.	20
2288	35 22 40	75 25 30	7	s., brk., sh.	--	69	6.45 “	20
2289	35 22 50	75 25 00	7	“	--	69	7.15 “	20
2290	35 23 00	75 24 30	10	“	--	69	7.45 “	20
2291	35 25 30	75 20 30	15	“	--	69	8.45 “	20
2292	35 27 20	75 16 30	17	“	--	70	9.32 “	20
2293	35 29 10	75 12 30	18	crs. s.	--	71	10.25 “	20
2294	35 31 00	75 08 30	19	crs. gy. s.	--	71	11.18 “	20
2295	35 32 41	75 04 30	22	“	--	73	12.03 P. M.	20
2296	35 35 20	74 58 45	27	“	--	71	1.15 “	20
2297	35 38 00	74 53 00	49	M., brk., sh.	--	73	2.18 “	20
2298	35 39 00	74 52 00	80	“	--	73	2.55 “	20
2299	35 40 00	74 51 30	296	bk. M.	--	73	3.50 “	20
2300	35 41 30	74 48 30	671	“	--	71	5.20 “	20
2301	35 11 30	75 05 00	59	crs. s.	75	77	6.10 A. M.	21
2302	35 14 00	75 03 00	49	s, C.	71	77	6.45 “	21
2303	35 17 00	75 01 00	41	fne. s.	--	77	7.11 “	21
2304	35 19 00	74 58 00	37	“	--	77	7.40 “	21
2305	35 23 00	74 51 30	58	“	66	79	8.36 “	21
2306	35 21 30	74 52 00	322	gy. M.	42	79	11.00 “	21
2307	35 42 00	74 54 30	43	gy. & bk. s.	57	70	4.11 P. M.	21
2308	35 43 00	74 53 30	45	“	--	71	5.17 “	21
2309	35 43 30	74 52 00	56	s., bk. spk.	--	71	6.08 “	21
2310	35 44 00	74 51 00	132	bk. M., s.	--	71	6.59 “	21

O. valida, but having more numerous arm-spines and much smaller rounded and sharp granules on the disk. It was taken at station 2035, in 2038 fathoms.

A curious orange species of *Hemieuryale* (*H. tenuispina* V., formerly *Astronyx tenuispina* V.), always occurs on *Scleroptilum elegans* in 1362 to 1608 fathoms. The disk and arms are covered with thin, rounded scales, not easily seen until dried, and a row of projecting plates runs along each side of the arms above.

ART. XXIII.—*Note on a Fossil Coal Plant found at the Graphite deposit in Mica schist, at Worcester, Mass.;* by JOSEPH H. PERRY.

IN the eastern part of Worcester, there is a granite knoll rising about three hundred feet above the surrounding country, and surrounded on all sides by the formation referred to by Professor Edward Hitchcock as mica slate or mica schist. In this mica schist is contained the coal deposit of Worcester as to whose age there has been much doubt. Professor E. Hitchcock believed it to be much earlier than the coal formation at Mansfield and Wrentham; and Professor C. H. Hitchcock assigns the mica schist to the Huronian.

I have recently found at the coal mine two specimens of a fossil coal plant of the genus Lepidodendron, the largest about eighteen inches long and six wide. The whole of one surface of the specimen and the larger part of the other are covered with the narrow rhombic scars, which where most distinct are about an inch long. The specimen has been examined by Professor J. D. Dana, by whom photographs were sent to Professor Lesquereux. The latter referred the fossil to the very rare species "*Lepidodendron* (*Sagenaria*) *acuminatum* of Gœppert (Foss. Fl. d. Uebergangsgebirge, 1852, p. 185, pl. xxxiii), partly, especially fig. 4, which however does not give so good a representation of the plant as the figure in Heer's Culm Fl., p. 291, plate xxii, fig. 4;" and he adds: "the specimen (photograph) is the first I have seen from America; the specimens from which Goeppert made the species were from the Carboniferous limestone of Silesia." He also says: "It is very much like a variety of the old and most common *Lepidodendron Veltheimianum* Sternb.; but it shows a marked difference in the disposition of the scars (cicatrices) to be arranged in a verti-

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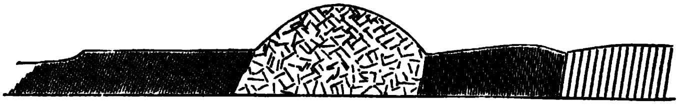
arms, long and slender, somewhat thorny. Mouth-papillæ unequal, mostly slender, spiniform, crowded outwardly, about 6 to 9 on each side of a jaw. Mouth-shields 4-lobed, the inner end angulated. Tentacle-scale large, flat; inner ones obtuse, others lanceolate. Diameter of disk 14^{mm}.

cal direction, forming ribs like those of Sigillaria." These ribs are really long spiral, and Lesquereux, although he has observed the same in another species, queries whether they are normal or not. The Carboniferous limestone of Silesia corresponds (as I am informed by Professor Dana) to the American Subcarboniferous.



The section represented in the accompanying figure has in the center the granite knoll, and extends to the northwest only far enough to show the mica schist resting against the granite. To the southeast the section cuts through the mica schist into the gneiss which lies to the east and southeast toward Mansfield and Wrentham. The gneiss and mica schist are conformable, having a general strike northeast and southwest, and where the section was made a dip of 75° to 85° to the northwest inclined away from the granite.

The outcrop of the coal-bearing strata of the mica schist is about half a mile northeast from the top of the granite knoll. Here the strike is northwest by southeast at about right angles to the strike of the mica schist outcropping not more than an eighth of a mile distant to the east. The dip is about 50° to the northeast, the strata leaning toward the granite. The fact that the same rock, identified by peculiar markings as well as by constitution, varies so greatly in dip and strike within so short a distance, indicates an additional disturbance to that which tilted the whole mica schist and gneiss to their present position and transformed them to their present condition. This additional disturbance was the forcing up from beneath of the granite knoll, breaking or bending the strata to the northeast and north, away from that to the east. This thorough working over of the rocks containing the carboniferous deposit has transformed this deposit for the most part into graphite; and in the specimen, mentioned above, the carbon is in the form of graphite though the scars of the plant are distinctly preserved.

It is my purpose to follow the rocks to the southeast and then to the west during the next season. So far as I have gone, I find my results agreeing quite closely with those of Professor E. Hitchcock.

High School, Worcester, Mass.

ART. XXIV.—*The Test Well in the Carboniferous Formation at Brownville, Nebraska;* by Professor L. E. HICKS of the University of Nebraska.

IT has long been a mooted question, both in the minds of geologists and of practical miners, whether there is coal in Nebraska that will pay for mining. The citizens of Brownville, Nemaha county, have been making a practical test of this matter for which they deserve much credit, since their test well has brought to light facts of great scientific interest and value irrespective of the economical results.

The boring was begun at an elevation of 919 feet above the level of the sea, and carried to the depth of 1,000 feet 10 inches, or 81 feet 10 inches below sea level. The surface rocks at Brownville are Upper Carboniferous and show traces of coal, as, for instance, in the west bank of the Missouri river just above the railway station. The drill penetrated the Lower Coal Measures but did not pass through them. These are the productive measures of the Carboniferous in Iowa and in the States farther east. Here, therefore, is the place to find coal if it exists at all in paying quantities in Nebraska. The only seam found in the Lower Coal Measures was one of bituminous coal of fair quality, 30 inches in thickness, at a depth of 820 feet 8 inches. The boring was carried 180 feet farther without encountering any more coal. Below the thirty inch seam nothing was encountered but the shales, limestones and sandstones ordinarily found in the Lower Coal Measures. This renders it improbable that any more coal would be found at greater depths, although the demonstration would have been more complete if the hole had been put down one or two hundred feet deeper.

Above the thirty inch seam three other thin seams were found; one 8 inches thick at a depth of 93 feet, another 14 inches thick at a depth of 242 feet, and a third 10 inches thick at a depth of 375 feet. These evidently belong to the Upper Coal Measures, as there is an interval of nearly 400 feet of barren rocks between them and the thirty inch seam. Immediately below the 14 inch seam is a stratum of sandstone 20 feet thick containing water strongly impregnated with salt and other minerals in solution, which flowed out at the top of the well.

Whether the thirty inch seam can be profitably worked at a depth of 820 feet is a question for the practical miner rather than for the geologist. It would at once be answered in the negative where fuel is plenty, but in this land of prairies and magnificent distances from productive mines the answer is not so much a matter of course.

I have a complete record of all the strata encountered, to the number of sixty-two, and will cheerfully furnish it upon application.

ART. XXV.—*Review of Hill's Supplement to Delaunay*; by JOHN N. STOCKWELL.

ASTRONOMERS in all parts of the world are always delighted on the appearance of any and all papers which are issued from the office of the American Ephemeris. A distinguishing characteristic of all these papers is the exhaustiveness with which the subjects deemed worthy of consideration are analyzed and discussed. Commencing in the year 1879, soon after the present eminent mathematician and astronomer, Professor Newcomb, became its Superintendent, a series of papers have been issued which embrace a wide variety of interesting astronomical subjects; and the ability which has been displayed in the preparation of these papers has gained for them a world-wide reputation. I was therefore unusually interested in the one which has recently appeared, entitled, "A Supplement to Delaunay's Lunar Theory, by G. W. Hill, Assistant American Ephemeris;" because it contained an investigation of a problem on which I had already bestowed much attention. From the vast extent to which the solution of the problem has been carried, it is evident that the eminent author was determined that the past reputation of these papers should suffer no detriment from this. The investigation covers 136 large quarto pages, and gives 165 inequalities in the longitude, 209 inequalities in the latitude and five inequalities in the radius vector, all of which are said to be correct to quantities of the seventh order. Of these 374 inequalities in the longitude and latitude, only seventeen exceed *one-twentieth* of a second of arc; and only two exceed *one* second. The vast development, however, shows the thoroughness with which the work was intended to be done, and if it is not what Mr. Hill claims for it in point of accuracy it is owing to some oversight rather than to deliberate neglect of any known cause of perturbation.

I do not purpose, however, to speak of the results of this solution which are common to all the solutions of this problem which I have seen, further than to say that it contains the same manifest absurdity in the principal equation of the latitude: namely, that it makes the coefficient of this inequality directly proportional to the cube of the sun's distance from the earth;

from which it follows that were the earth and moon to revolve around the sun in their present relations to each other, but at the distance of Neptune, the inequality would be more than 27,000 times greater than at present. This single fact ought to justify the suspicion that possibly the entire solution is erroneous. This result cannot be regarded as an oversight, but rather as a faulty solution, the origin of which it is easy to explain.

But I find on careful examination that there has indeed been a remarkable oversight committed in the developments of this work, and that not more than *two* of the inequalities, if indeed *any* of them are deserving of any confidence in point of accuracy; nor can these two be correct to terms of a higher order than the third or fourth.

In order to give a general explanation of the oversight which seems to have been committed in this work, I would observe that Mr. Hill has first determined the disturbing force which is due to the earth's figure on the supposition that the moon's motions are not affected by the sun's attraction. The real disturbing force of the earth is, however, a function not only of the earth's figure, but also of the moon's coördinates, and since the moon's coördinates are affected by the sun's attraction, it follows that there must be a modification of the earth's force arising from that cause. This effect of the sun Mr. Hill has correctly allowed for, and it would therefore *seem* at first view, that if he has allowed for the earth's force and also for its modification by the sun's action, that the whole effect of the earth's figure on the moon's motion would be accurately determined by his investigation. But in reality the sun's disturbing force is modified by the earth's figure to terms of the same order as those by which the earth's force is modified by the sun's attraction. It is therefore necessary to consider these terms if we propose to carry the approximations to terms of the order of the products of the disturbing masses. But these terms Mr. Hill has entirely omitted; and hence it follows that all the terms of the order of the products of the disturbing masses in his investigation must necessarily be erroneous, no matter to what extent the development in terms of the eccentricity and inclination may be carried.

It may, however, be more satisfactory to mathematicians to have the preceding statements translated into symbolic language. For this purpose let us put R_e and R_1 for the disturbing functions due to the earth and sun respectively, and also put R for the total disturbing function, we shall have

$$R = R_e + R_1 \qquad (1)$$

But since R is a function of the moon's coördinates r, v and

θ, we shall have the whole variation of R due to any variations in the coördinates by means of the equation

$$\left.\begin{aligned}\delta R &= \left(\frac{dR}{dr}\right)\delta r + \left(\frac{dR}{dv}\right)\delta v + \left(\frac{dR}{d\theta}\right)\delta\theta \\ &= \left(\frac{dR_0}{dr}\right)\delta r + \left(\frac{dR_0}{dv}\right)\delta v + \left(\frac{dR_0}{d\theta}\right)\delta\theta + \left(\frac{dR_1}{dr}\right)\delta r + \left(\frac{dR_1}{dv}\right)\delta v \\ &\qquad + \left(\frac{dR_1}{d\theta}\right)\delta\theta\end{aligned}\right\} \quad (2)$$

Now δr, δv and $\delta\theta$ denote the total perturbations of the coördinates; they must therefore be the sums of the perturbations arising from the action of the earth and sun. Putting therefore $\delta_0 r$, $\delta_1 r$, $\delta_0 v$, $\delta_1 v$, $\delta_0\theta$, $\delta_1\theta$ for the variations arising from the action of the earth and sun respectively, we shall have

$$\delta r = \delta_0 r + \delta_1 r \quad \delta v = \delta_0 v + \delta_1 v \quad \delta\theta = \delta_0\theta + \delta_1\theta \qquad (3)$$

If we substitute these values of δr, δv and $\delta\theta$ in equation (2), and retain only the terms depending on the products of the masses, we shall find,

$$\left.\begin{aligned}\delta R = &\left(\frac{dR_0}{dr}\right)\delta_1 r + \left(\frac{dR_0}{dv}\right)\delta_1 v + \left(\frac{dR_0}{d\theta}\right)\delta_1\theta \\ &+ \left(\frac{dR_1}{dr}\right)\delta_0 r + \left(\frac{dR_1}{dv}\right)\delta_0 v + \left(\frac{dR_1}{d\theta}\right)\delta_0\theta\end{aligned}\right\} \quad (4)$$

Now Mr. Hill has taken account of only the first three terms of this equation and has omitted all consideration of the last three. But if Mr. Hill's values of $\delta_0 r$, $\delta_0 v$, $\delta_0\theta$ are correct, these last three terms are of much more importance than the first three. Indeed it is one of the curiosities or rather paradoxes of the whole theory, that, if Mr. Hill's value of $\delta_0 r$, $\delta_0 v$, $\delta_0\theta$ be substituted in the last equation the value of δR will be equal to $-R_0$, and the whole disturbing function arising from the earth's figure will vanish; at least as far as the terms depending on the coefficient β_2 of Mr. Hill's work are concerned, and hence all the inequalities depending on that coefficient ought to vanish also. But if the values of $\delta_0 r$, $\delta_0 v$ and $\delta_0\theta$ which I have determined, are substituted in the last three terms of equation (4) we get rational and consistent values, of the same order of magnitude as Mr. Hill has derived from the first three terms. This is a strong corroboration of the statement which I made at the Philadelphia meeting of the American Association in September, namely, that the computed values of the lunar inequalities arising from the earth's figure are erroneous.

This fundamental defect in the theory, to which I have called attention, renders it entirely valueless as a scientific deduction, so that a more detailed analysis of the work is unnecessary in this place; but there is one point of especial interest to which I would like to call attention, and that is the secular equation of the longitude which depends on the obliquity of the ecliptic. By referring the equator and the moon's. coördinates to a fixed plane instead of to the variable ecliptic, Mr. Hill has seemingly obtained a solution which is free from secular terms, but, if we remember that in this case the inclination of the orbit becomes variable to the same extent as the obliquity of the ecliptic in my solution, we shall obtain precisely the same secular equation. La Place, nearly a hundred years ago, called attention to the fact that the secular motion of the ecliptic produced a secular change in the moon's declination, and since this declination is the principal variable quantity in the expression of the earth's disturbing force, it seems strange that Mr. Hill should have entirely overlooked one of its most obvious consequences.

Although the defect to which I have called attention renders the work of no value as a scientific deduction, it is nevertheless really valuable on account of the elegance and symmetry which pervades its vast expansion; and it may be examined with great advantage by the matured mathematician as well as by the younger student of celestial mechanics.

Cleveland, Nov. 8, 1884.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Relation between the Velocity of Evaporation of Liquids and their Molecular weights.*—SCHALL has continued his researches upon the connection between the time of evaporation of liquids and their molecular weights.* In place of measuring the increase in the vapor volume, he has now measured the time required for the liquid to diminish by a given amount. The apparatus (a figure of which is given) consists of a bent tube carefully calibrated, to hold the liquid, enclosed in a flask containing a suitable vapor in contact with its liquid as a source of heat. The progress of the evaporation was observed with a cathetometer. In order to determine the density of the liquids used, at their boiling points, a specific gravity flask filled with the liquid was placed in a cylinder containing the same liquid in ebullition. When the liquid had reached the required temperature, the sp. gr. flask was closed with a tight-fitting stopper,

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* This Journal, III, xxvii, 233, March, 1884.

cooled and weighed. Taking the liquids in pairs, the molecular weight of either one is calculable by the formula $m = \frac{m'Dt'}{D't}$, in which m, D and t represent the molecular weight, the density at the boiling point and the time of evaporation respectively. Thus for aniline D = 0·8731 and for phenol D′ = 0·9208. In two experiments t for the former was 3·8 minutes and t' for the latter 3·9 minutes. Since the molecular weight of phenol is 94, the molecular weight of aniline $= \frac{94 \times 0{\cdot}8731 \times 3{\cdot}9}{0{\cdot}9208 \times 3{\cdot}8} = 91{\cdot}48$. Two other experiments gave 91·91, the calculated value being 93. So, calculating the molecular weight of phenol, the values 95·57, 95·11, 95·11 were obtained; the calculated molecular weight being 94. Benzoyl chloride (140·5) and ethyl benzoate (150) gave for the former the values 144·3 and 144·5; and for the latter 145·7 and 145·2. Twenty-four similar pairs of liquids were examined with correspondingly close results. The following are the conclusions of the paper: 1st, when liquids are evaporated in their own vapors, the times of evaporation of equal weights are inversely proportional to their molecular weights. 2d, the latent heats of evaporation are proportional to the times of evaporation of equal weights of the liquids. 3d, at the boiling point, liquid acetic acid has the molecular weight 89·8 and formic acid, 69.—*Ber. Berl. Chem. Ges.*, xvii, 2199, October, 1884. G. F. B.

2. *On the Quantitative determination of Metals by Electrolysis.*—In a third paper on this subject, CLASSEN gives the results of his experiments on the quantitative electrolysis of metallic solutions by means of the magneto-electric current. For this purpose he uses a small Siemens dynamo, driven from a counter-shaft as usual. This counter-shaft however has a cone pulley and is driven from another counter-shaft having upon it a similar cone pulley and also a fast and loose pulley, over which runs the belt from the main shaft. By this arrangement the speed of the dynamo may be varied at pleasure from 100 to 700 revolutions per minute. By means of a resistance box, placed in the main circuit, the coils of which vary from 0·01 to 3 ohms the current-strength may also be varied. So that by both these arrangements the author has command of a current varying at will from 0·02 to 7·46 ampères. On a vertical rod connected with the negative electrode is a ring for supporting the platinum dish containing the solution. An arm sliding on the same rod, but insulated from it, supports the positive electrode. The platinum dish used weighs from 35 to 37 grams, is 9 cm. in diameter and 4·2 cm. deep and holds about 225 c.c. water. Care is required to have it perfectly smooth and clean. For the determination of copper and of cadmium the double ammonium oxalate solution is preferred. The current used should be about 0·02 ampère, such as would be obtained by joining two Bunsen cells in parallel circuit. The separation is complete in from ten to twelve hours for about 0·15 grm. copper, the end reaction being

determined by ferrocyanide. For 0·1425 grm. of copper used in six experiments the process gave 0·1425 grm. in four and 0·1420 in two. In the case of cadmium, 0·1235, 0·1480, 0·2385 grms. were used and 0·12325, 0·1470 and 0·2380 recovered. For the separation of iron and copper, solutions of iron alum and copper sulphate were mixed with ammonium oxalate in excess, and electrolyzed. After the copper was separated, more ammonium oxalate was dissolved in the solution and the iron thrown down electrolytically. Copper was separated from cobalt and nickel in the same way; as also from chromium, magnesium, aluminum, manganese and zinc. In the latter case the solution is made acid with sulphuric acid. For the precipitation of antimony, its solution in sodium monosulphide free from polysulphide is used. Tin gives good results when thrown down from solution in ammonium sulphide. Platinum is readily estimated quantitatively by electrolyzing its solution in hydrochloric acid or ammonium oxalate with a current of half the above strength. The author gives the results of the electrolytic separation of iron from cobalt, nickel, zinc and uranium, of zinc from chromium and uranium, of cobalt from chromium, all of which are accurate.—*Ber. Berl. Chem. Ges.*, xvii, 2467, Nov. 1884. G. F. B.

3. *On the Specific Gravity of Monohydrated Sulphuric acid.*—MENDELEJEFF has reviewed all the determinations which have been made of the specific gravity of sulphuric acid monohydrate, and concludes that those of Marignac in 1853, giving 1·8372, of Kohlrausch in 1876 giving 1·8373, of Schertel in 1882 giving 1·8371, which agree with those made by him in 1884 giving 1·8371, all at 15°/4° in vacuo, are the more probably correct, since they agree to 0·0002.—*Ber. Berl. Chem. Ges.*, xvii, 2536, Nov. 1884. G. F. B.

4. *On Octosulphates.*—WEBER has succeeded in preparing a series of sulphates which are perfectly definite and which contain a very large proportion of the acid radical. For the preparation of the potassium salt, one leg of a U tube is filled with pure sulphuric oxide and the other with perfectly dry potassium sulphate. The tube is then sealed, inverted and slowly heated in a water bath. Combination takes place and two layers of liquid appear in the tube. By slow cooling, beautiful well-formed crystals separate from the lower layer, apparently quadratic in form. The tube is now opened and the still liquid oxide poured off. It is then again sealed, heated to fuse the crystals, allowed to cool and the liquid oxide again poured off; the operation being repeated till the crystals are free from oxide. The composition of these crystals was determined by synthesis, a weighed quantity of potassium sulphate being used. When 0·3455 grm. K_2SO_4 was used, the resulting compound weighed 1·488 grams; showing that 76·78 per cent. of it was sulphuric oxide. This corresponds to the formula $K_2O.(SO_3)_8$ or $K_2SO_4.(SO_3)_7$. Similar sulphates were obtained with rubidium, cæsium, ammonium and thallium. Sodium, lithium and silver did not appear to form them, at least not readily.—*Ber. Berl. Chem. Ges.*, xvii, 2497, Nov. 1884. G. F. B.

5. *On the Separation of Arsenic from Tin and Antimony.*—At the suggestion of Classen, **Hufschmidt** has made a series of experiments on the separation of arsenic from antimony and tin by distillation of its chloride. He finds that if the arsenical solution is brought to about 250 c.c. by the addition of concentrated hydrochloric acid and then completely saturated with HCl gas and distilled in a current of this gas, the volatility of the arsenous chloride is such that nearly the whole of it is removed before the first drops of distillate enter the receiver. After about 50 c.c. of the distillate has collected in the receiver, no trace of arsenic can be detected in the subsequent portions. To condense this very volatile body a Woulfe's bottle of about 900 c.c. is used as a receiver, containing from 300 to 400 c.c. of water or of potassium hydrate solution of sp. gr. 1·1 to 1·2. The results of the separations effected by this method which are given seem to be entirely satisfactory. —*Ber. Berl. Chem. Ges.*, xvii, 2245, Oct. 1884. G. F. B.

6. *On the Purification of Arseniferous Zinc.*—**L'Hôte** has examined for arsenic the commercial zincs found in France, and finds, for one kilogram of sheet zinc, Vieille-Montagne, 36, 30 and 20 milligrams arsenic in three samples, Harfleur 10·5 mgrms., and Company Asturienne 26 milligrams. The slab zinc, Vieille-Montagne and Silesia, gave only traces. In order to purify this arseniferous zinc the author recommends to project into the melted metal one to one and a half per cent of anhydrous magnesium chloride. On stirring, white fumes of zinc chloride mixed with arsenous chloride are evolved. If now the metal be poured into water to granulate it, the zinc obtained is free from arsenic and is readily attackable by one-tenth sulphuric acid. The same process will free zinc from antimony.—*Ann. Chim. Phys.*, VI, iii, 141, Sept. 1884. G. F. B.

7. *On Perseite, a new Sugar.*—**Muntz** and **Marcano** have described a new sugar obtained from the seeds of the *Laurus persea*, a tree growing in the tropics. This sugar had been observed by Avequin in 1831, and by Melsens later; but it was by them supposed to be mannite. It is extracted by boiling alcohol from which it crystallizes on cooling. Analysis gives it the formula $C_{12}H_{14}O_{12}$, isomeric with mannite. Its point of fusion is 183·5°–184°, while that of mannite is 20° lower. It is very soluble in hot, less so in cold water. Even in concentrated solution it has no action in the polarimeter. On adding borax however to a 4 per cent solution it gave a rotation to the right of 0·55°. It does not reduce copper solutions and is not fermentable. Boiling nitric acid converts it into oxalic acid, without the production of mucic acid. A mixture of strong nitric and sulphuric acids gives a trinitro-perseite which detonates violently by a blow and spontaneously decomposes.—*Ann. Chim. Phys.*, VI, iii, 179, Oct. 1884. G. F. B.

8. *Synthesis of a Coloring matter resembling that of Litmus.*—**Traub** and **Hock** have shown that when resorcin is heated with a small quantity of sodium nitrite and some water to a tempera-

ture not exceeding 150°, a deep blue color is developed, which has in its properties a very close resemblance to that of litmus. It readily becomes red on the addition of acids and is very sensitive as an indicator for titrition. In alkali-solution it shows a broad band in its spectrum near the line D which shades off toward E. In acid solution, it cuts off the more refrangible portions of the spectrum.—*Ber. Berl. Chem. Ges.*, xvii, 2615. G. F. B.

9. *Use of the induction Spark in Spectrum Analysis.*—M. DEMARÇAY has modified the method of M. Lecoq de Boisbaudran by employing an induction coil made of comparatively large and short wire. By means of this induction coil atmospheric lines of the second order are not obtained and rarely the nebulous bands of azote or the lines of the electrodes. The spark has sufficiently high temperature to give the spectra of all the known elements without the employment of strong currents. The coil employed by M. Demarçay under the action of 6 to 9 bichromate cells (zincs $0^{m}{\cdot}10$ to $0^{m}{\cdot}16$) coupled 2 or 3 for quantity and 3 for tension gave a spark of 5^{mm}. The inner diameter of the bobbin was $0^{m}{\cdot}115$ and its length was $0^{m}{\cdot}23$. The diameter of the wire of the primary was 1^{mm}, it weighed $1^{kg}{\cdot}320$ and was coiled in two layers. The diameter of the wire of the secondary coil was also 1^{mm} and it weighed $3^{kg}{\cdot}400$. The bundle of iron wires was 27^{mm} in diameter and weighed 680^{gr}. The condenser was three times the dimensions usually employed with induction coils of this size. —*Comptes Rendus*, Dec. 8, 1884, p. 1022. J. T.

10. *Effect of the Magnetic field upon Light.*—CORNU in a mathematical paper gives his reasons for believing that a double refraction of a peculiar nature exists in a magnetic field in a direction at right angles to the lines of force. This double refraction has not yet been observed; but Cornu shows that the quantity to be observed is of the order of dimension of a wave length and ought therefore to be detected with the powerful means now at our command.—*Comptes Rendus*, Dec. 15, 1884. J. T.

11. *A new Galvanometer.*—J. ROSENTHAL describes a new form of galvanometer which is said to have great range and great sensitiveness, and is made by Edelmann, of Munich, for about forty dollars. Its novelty consists in the needle which is a horse-shoe magnet suspended by a long fiber attached to its neutral point. The poles of the magnet are provided with horizontal pole pieces, which are quadrantal arcs of a circle the center of which lies in the axis of suspension of the horse-shoe. These pole pieces can play within the axis of two galvanometer bobbins placed on opposite sides of the vertical plane of the horse-shoe when the plane coincides with the magnetic meridian. When an electric current passes through the coils, these pole pieces are respectively drawn in and repelled by the two bobbins. In this way the poles of the magnet can be brought very near the center of the coils. Rosenthal gives the results of various measurements which he has made to test the sensitiveness of this instrument. Without compensation by an exterior magnet $0{\cdot}1^{mm}$ deflection corres-

ponds at a scale distance of 2700^{mm} to $\frac{54}{10^{10}}$ of an ampère. With compensating magnet $0 \cdot 1^{mm}$ deflection to $\frac{12}{10^{10}}$ of an ampère. A difference of 10° C. between the junctions of one german silver and iron thermo-element gives a deflection of 120^{mm} through 1000 ohms resistance at a scale distance of 2700^{mm}.—*Annalen der Physik und Chemie*, No. 12, 1884, pp. 677–686. J. T.

12. *Electrical resistance of microphone contacts during movement.*—The theory of the action of the microphone is still little understood. Otto Boekman, in his paper, gives the results of many measurements upon polished carbon contacts with different current strengths, and with varying pressure upon the contacts. The results are expressed graphically, and the author concludes that the resistance of polished carbon contacts, under constant pressure and with constant current strengths, is smaller during movement than during rest. After cessation of the movement the contacts return to their original resistance. The difference between the resistance of movement, and that of rest is greater, the greater the original resistance—or which is the same thing—the less the original pressure. The resistance of movement with constant pressure and decreasing strength of current increases and returns to its original amount, after cessation of movement. The resistance decreases with diminished movement and diminished strength of tone of the tuning fork interrupter, the pressure and the strength of the electrical current remaining the same. The resistance during the movement is with same strength of tone and strength of current not dependent upon the number of vibrations, which the movement indicates—it is also independent of the pitch.—*Ann. Phys. Chem.*, No. 12, 1884, pp. 651–665. J. T.

13. *Resistance of the Siemens Mercury unit.*—H. Wild communicates in detail the results of his new measurements of the mercury unit and obtains the value 1. S. E.$=0 \cdot 94315$ ohm, and therefore concludes that $106 \cdot 027^{cm}$ of mercury, one square millimeter in section at 0° C., represents the resistance of an ohm.—*Annalen der Physik und Chemie*, No. 12, 1884, pp. 665–677. J. T.

II. GEOLOGY AND NATURAL HISTORY.

1. *A Scorpion from the Upper Silurian.*—A fossil Scorpion has been found in the Upper Silurian (Ludlow) of Gotland, Sweden, and named by MM. Torell and Lindström, *Palæophonus nuncius.* The specimen is well preserved and shows clearly the cephalothorax, the abdomen with seven dorsal plates, and the tail, consisting of six segments, the last pointed to form the poison-dart. The sculpture of the surface consists of tubercles and longitudinal ridges, and is exactly as in recent scorpions. One of the stigmata is visible on the right side, proving that the animal respired air.

Further, a fossil scorpion was obtained last year by Dr.

Hunter, of Carluke, from the Upper Ludlow beds of Lesmahago, in Lanarkshire. Owing to the ill health of Mr. B. N. Peach, to whom it was sent, it was not studied until a photograph of the Swedish species was received from Dr. Lindström. The two are closely allied, and may be of the same species.—*Ann. and Mag. Nat. Hist.*, January, 1885, p. 76, citing the note on the Swedish Scorpion from *Comptes Rendus*, December 1, 1884, p. 984.

2. *Dinocerata, a Monograph of an Extinct Order of Gigantic Mammals;* by OTHNIEL CHARLES MARSH. 56 plates and 200 woodcuts. i–xviii and 237 pp. 4to. Washington, 1884. *United States Geological Survey, Volume X.* Advance copy issued with the permission of the Director.—A review of this important memoir will appear in the next number of this Journal.

3. *Names of extinct Reptiles;* by O. C. MARSH.—The name *Amphisaurus*, given by the writer to a genus of Triassic reptiles, proves to be pre-occupied, and may be replaced by *Anchisaurus*. The name of the family would then be *Anchisauridæ*. *Camptonotus*, applied to a genus of Jurassic reptiles, has also been used, and *Camptosaurus* may be substituted. *Limnophis*, already in use, may be replaced by *Lestophis*.

4. *Botanical Necrology for* 1884.—The list should begin with the name of a devotee to botany who died some time in the year 1883, namely:

AUGUSTUS FENDLER. After Dr. Engelmann's death, the beginning of a notice of Mr. Fendler was found upon his table, from which it was learned that he had died at Trinidad, some time previous. Inquiries sent to the Port of Spain, where he had for several years resided, remain unanswered. An autobiographical account which he addressed to a correspondent (and which, with some of his letters, we hope will before long be printed), enables us to state that Mr. Fendler was born at Gumbinnen, on the easternmost borders of Prussia, January 10, 1813, lost his father in infancy, was sent to the gymnasium of the town when twelve years old, but was at sixteen apprenticed to the town clerk, where, perhaps, he perfected the neat and clear hand-writing with which his correspondents are familiar. Having a fondness for mathematics and chemistry, he obtained, in 1834, upon examination, a nomination to the Royal Polytechnic School at Berlin, but relinquished it after a year on account of delicate health; in 1836 he came from Bremen to Baltimore, "with a couple of dollars in his pocket," worked in a tan-yard in Philadelphia, then in a lamp factory in New York; in 1838, traveled in the most economical way to St. Louis, which required thirty days, and was employed by a lamp-maker who made "spirit-gas" for lighting public houses, coal-gas being then unknown so far west. Soon after he made his way to New Orleans and to Texas, where he was witness to the ravages of yellow fever in the summer and fall of 1839; he returned to Illinois, broken in health and empty in purse, taught school for some time, then, the spirit of wandering and of solitude coming strongly upon him, he took possession of an uninhabited island in the Missouri River, about 300 miles above St. Louis, where he enjoyed a hermit's life for six months, and until a great spring rise of the river threatened to sweep away his cabin, when he took to his canoe, and dropped down the stream among the floating logs and masses of ice. In 1844 he returned to Old Prussia on a visit, at Königsberg made the acquaintance of Ernst Meyer, the professor of Botany, and learned from him—what he would have been most glad to know before—that dried specimens of plants for the herbarium might be disposed of at a reasonable price. Returning to St. Louis, he began to collect plants in this view, took the specimens to Dr. Engelmann, who gave him botanical assistance and encouragement. In 1846 Dr. Engelmann and the writer of this notice obtained permission for the transportation of Mr. Fendler and his luggage along with the body of U. S. troops which took possession of Santa Fé, New Mexico; there he remained for about a year, and made his well-known New Mexican collection, the first fruits of the botany of that interesting district. In 1849, he attempted another western botanical expedition, this time with Salt Lake in view. But on the plains he lost all his drying paper in a flood of the Little Blue River, and he returned to St. Louis, to find that all his collections, books, journals and other possessions had been burnt in the great conflagration which had just devastated that city. He now sought a different climate, and, at the approach of winter, went to the Isthmus of Panama for four months, made at Chagres an interesting botanical collection, returned by way of New Orleans to Arkansas, and to Memphis on the Tennessee side of the river, where for three years he carried on the camphene-light business, botanizing in the vicinity when he could. In 1854, the introduction of gas having made his occupation unprofitable, and a craving for new scenes being strong upon him, he sailed for La Guayra, went up to Caraccas and thence to Colonia Tovar, 6,500 feet above the sea, built his cabin on the mountain side, where he lived four or five years and amassed his large and fine Venezulean collections of dried plants, so well known in the principal herbaria of the world. His principal companions were his thermometer and barometer, and his careful meteorological observations were published by the Smithsonian Institution, in the report of the year 1857. Returning to Missouri, in 1864, he bought some wild land at Allenton, cultivated and lived on it for seven years (except one winter passed in the herbarium at Cambridge), having the companionship and assistance of a half-brother who had joined him, and whom, being rather feeble-minded, he took care of for the rest of his life. In 1871, having sold his place in Missouri, he returned again to Prussia, intending to remain in his native country. But he soon longed for the New World, to which he returned in 1873; he settled in Wilmington, Delaware, where, having the botanical companionship of Mr. Canby, he again interested himself in his favorite pursuits,—but now much more in speculative physics. For years the thoughts of his solitary hours had turned upon the cause of gravitation and its probable connexion with other forces, and while at Wilmington he wrote (and unhappily printed at his own expense) a thin octavo volume, entitled "The Mechanism of the Universe." Repeated attacks of acute rheumatism constrained him to seek again a tropical climate, this time the island of Trinidad. He and his brother landed at the Port of Spain in June, 1877, where he passed the remainder of his days, living mainly on the products of the small plot of land which he purchased, renewing his old interest and activity in making botanical observations and collections, especially among the Ferns, of which he sent to Professor Eaton collections worthy of his better days. But, having exhausted in this respect the field within his immediate reach, and lost the vigor needed for laborious excursions, little had been heard of him for the past few years, and it is only indirectly that the fact of his death has been made known to us.

It is needless to say that Fendler was a quick and keen observer and an admirable collector. He had much literary taste, and had formed a very good literary style in English, as his descriptive letters show. He was excessively diffident and shy, but courteous and most amiable, gentle, and delicately refined. Many species of his own discovery commemorate his name, as also a well-marked genus, a Saxifragaceous shrub, which is winning its way into ornamental cultivation.

Fendler's death probably did not long precede that of his patron and friend,

George Engelmann, whose lamented decease, on the fourth of February, 1883, at the age of 75, was announced in this Journal at the time; and whose biography is given in the July number. There is also an interesting memorial in Science, April 4, by his friend and associate Professor Sargent.

Samuel Botsford Buckley died at Austin, Texas, February 18, 1883, in the 75th year of his age. He was born in Yates Co., New York, near Pen Yan, on the 9th of May, 1809, was educated at Wesleyan University, Middletown, Conn., became for some time a teacher, at first in Illinois, where his earliest botanical collections were made, then in Alabama and some of the neighboring States, and was one of the earliest explorers of our time in the southwestern portion of the Appalachian Mountains. His first and probably his best paper, describing some new species of this region, was published in this Journal in 1843, at the same time with the characters of the remarkable genus which botanically commemorates him, viz: the *Buckleya distichophylla* of Torrey, a peculiar and graceful Santalaceous shrub, of which Mr. Buckley first discovered the flowers and fruit, Nuttall before him having found only the foliage. In later years Mr. Buckley resided mainly in Texas, where he was appointed State Geologist in 1866; but he was the naturalist of the State Survey much earlier. Many new species and some genera were published by him in the years 1860–62, in the Proceedings of the Academy of Natural Sciences at Philadelphia. His zeal in botany and his knowledge of plants of the Southern States in their native habitats were great; his opportunities and training for doing descriptive botanical work were not of the best. It is said that he "was several years engaged in writing a work on the trees and shrubs of America, which is unfinished." An appropriate biographical notice of Mr. Buckley, by S. H. Wright, is in the eleventh volume of the Bulletin of the Torrey Botanical Club.

JOHN WILLIAMSON, of Louisville, Kentucky, died June 17, 1884,—a young man, of Scottish birth, an amateur botanist, chiefly in Ferns; the author of the Ferns of Kentucky, in two editions, illustrated by graceful and characteristic figures printed directly from the author's etchings, which are wonderfully good. We need here only refer to two memorials of this gifted artist and pteridologist, from most capable and loving hands, one by Mr. G. E. Davenport in the Botanical Gazette, ix, 122; the other by J. H. R. in the Bulletin of the Torrey Botanical Club, xi, 104.

Of Botanists in Europe the principal losses in 1884 are those of

JOHN HUTTON BALFOUR, one of the founders of the Edinburgh Botanical Society in 1836, an eminent teacher and a man of various learning; Professor of Botany first at Glasgow, but since 1846 at Edinburgh, his native town, where, after a few years of superannuation, he died, February 11, 1884, in the 76th year of his age.

HEINRICH ROBERT GŒPPERT, Professor of Botany at Breslau, eminent as a teacher and in Paleo-botany, died May 18, 1884, in the 84th year of his age.

GEORGE BENTHAM, the greatest descriptive and taxonomical botanist since DeCandolle and Brown, died Sept. 20, close upon his 84th birthday. A memorial finds a place in the present number of this Journal, p. 103. A. G.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The late Henry Watts, F.R.S., F.C.S.*—A recent number of the Chemical News (Dec. 5, 1884), states that in November last, at a meeting held at the Royal Institution, a committee was formed to collect funds for the benefit of the wife and children of the late Mr. Henry Watts. It appears that notwithstanding his remarkable industry, and the many contributions which he made to science, the money return for his labors was small and only sufficed for daily wants, and now at his death his invalid wife and ten children find themselves with almost nothing to depend upon. The income available amounts to the pitiful sum of £100 a year, and only two of the children are in a position to render assistance. In view of the great benefit which every chemist has received from the almost unremunerated labors of Mr. Watts, notably from his great Dictionary of Chemistry, the appeal which the committee now makes to chemists at home and abroad should receive a prompt and liberal response. All contributions, whether large or small, will be welcome. Subscriptions may be sent to Dr. E. Waller, of New York, (4th Avenue and 49th St.).

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXVI.—*Professor Marsh's Monograph of the Dinocerata.*[*]

THE previous numbers of this Journal have contained all, or nearly all, of the original papers on the *Dinocerata* by the author of the present memoir, and it is especially fitting, on the completion of his investigations, that at least an abstract of the main points of the volume should also be placed here on record. The extracts which follow have been selected with a view to give to the reader a brief sketch of the discovery, and general characteristics, of this remarkable group of mammals, and their relations to other members of the same class, living and extinct.

The general plan of the present volume, essentially the same as that of the author's previous memoir on the *Odontornithes*, is especially worthy of notice, and might well serve as a model for all monographs on similar subjects. In the Introduction, the history of the discovery of the *Dinocerata*, and their distribution in time and space, are first presented. A description of the various parts of the skeleton in the typical genera of the order next follows, richly illustrated, with restorations of two forms, and the biologist has then before him a vivid picture of characteristic members of the group. In the Appendix, is a Synopsis of all the known genera and species, with many details for the systematic zoölogist.

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[*] *Dinocerata*, a Monograph of an Extinct Order of Gigantic Mammals; by Othniel Charles Marsh. 56 plates and 200 woodcuts. i-xviii and 237 pp., 4to. Washington, 1884. United States Geological Survey, vol. x. Advance copy issued with the permission of the Director.

The volume ends with a Bibliography of all the important literature on the *Dinocerata*, and thus the librarian, also, has at hand material ready for a catalogue. In most volumes on palæontology, as well as on other branches of natural science, these four divisions are mixed together, so that each different class of readers must seek out what it needs with much labor.

The author's general plan of publication was given in the introduction to his previous memoir, and this is supplemented in the preface of the present volume, from which we quote the following:

"The present memoir is the second of a series of Monographs designed to make known to science the Extinct Vertebrate Life of North America. In the first volume, on the Odontornithes, or Birds with Teeth, the author gave the result of his investigations of that remarkable group, which he discovered in the Cretaceous deposits on the Eastern slope of the Rocky Mountains.

"This second Monograph contains the full record of a peculiar order of Mammals, which the author also brought to light in the early Tertiary strata of the great central plateau of the continent.

"In preparing the present volume, it has been the aim of the author to do full justice to the ample material at his command, and, where possible, to make the illustrations tell the main story to anatomists. The text of such a memoir may soon lose its interest, and belong to the past, but good figures are of permanent value in all departments of Natural Science. What is now especially needed in Palæontology is, not long descriptions of fragmentary fossils, but accurate illustrations of characteristic type specimens. In the fifty-six lithographic plates, and nearly two hundred original woodcuts, in the present volume, it is believed that this requirement is fairly met; since all the more important specimens of the *Dinocerata* now known are represented, and at least one figure is given of every species."

In the Introduction, the author gives an account of the discovery of the *Dinocerata*, with the localities and geological horizon in which they are found, beginning as follows:

"Among the many extinct animals discovered in the Tertiary deposits of the Rocky Mountain region, none, perhaps, are more remarkable than the huge mammals of the order *Dinocerata.* Their remains have hitherto been found in a single Eocene lake-basin in Wyoming, and none are known from any other part of this country, or from the Old World. These gigantic beasts, which nearly equaled the elephant in size, roamed in great numbers about the borders of the ancient tropical lake in which many of them were entombed.

"This lake-basin, now drained by the Green River, the main tributary of the Colorado, slowly filled up with sediment, but remained a lake so long that the deposits formed in it, during Eocene time, reached a vertical thickness of more than a mile. The Wasatch Mountains on the West, and the Uinta chain on the South, were the main sources of this sediment, and still protect it, but the Wind River range to the North, and other mountain elevations, also sent down a vast amount of material into this great fresh-water lake, then more than one hundred miles in extent.

"At the present time, this ancient lake-basin, now six to eight thousand feet above the sea, shows evidence of a vast erosion, and probably more than one-half of the deposits once left in it have been washed away, mainly through the Colorado River. What remains forms one of the most picturesque regions in the whole West, veritable *mauvaises terres*, or bad lands, where slow denudation has carved out cliffs, peaks, and columns of the most fantastic shapes, and varied colors. This same action has brought to light the remains of many extinct animals, and the bones of the *Dinocerata*, from their great size, naturally first attract the attention of the explorer.

"The first remains of the *Dinocerata* discovered were found by the author, in September, 1870, while investigating this Eocene lake-basin, which had never before been explored. Various remains of this group were also collected by other members of the expedition, and among the specimens thus secured was the type of *Tinoceras anceps*, described by the author in the following year, and now more fully in the present volume. In the same geological horizon with these remains, a rich and varied vertebrate fauna, hitherto unknown, was found.

"Among the animals here represented were ancestral forms of the modern horse and tapir, and also of the pig. Many others were found related to the recent Lemurs; also various Carnivors, Insectivors, Rodents, and small Marsupials; and of still more importance, remains were here brought to light of another new order of mammals, the Tillodonts, quite unlike any now living. Crocodiles, tortoises, lizards, serpents, and fishes also swarmed in and about the waters of this ancient lake, while around its borders grew palms, and other tropical vegetation.

"The remarkable Eocene basin North of the Uinta Mountains, where alone the *Dinocerata* had been found, offered so inviting a field for exploration, that in the spring of the following year, 1871, the author began its systematic investigation. An expedition was again organized, with an escort of United States soldiers, and the work continued during the entire season. Among the very large collections thus secured, were numerous specimens of the *Dinocerata*, which furnished important characters of the group.

"In the succeeding spring, 1872, the explorations in this region were continued, and soon resulted in the discovery of the type specimen, including the skull, and a large portion of the skeleton, of *Dinoceras mirabile*, and on this new genus the author based the order *Dinocerata*.

"Other important specimens, obtained at this time, and described by the author, were the types of *Dinoceras lucare*, *Tinoceras grande*, *Tinoceras lacustre*, and others of scarcely less interest.

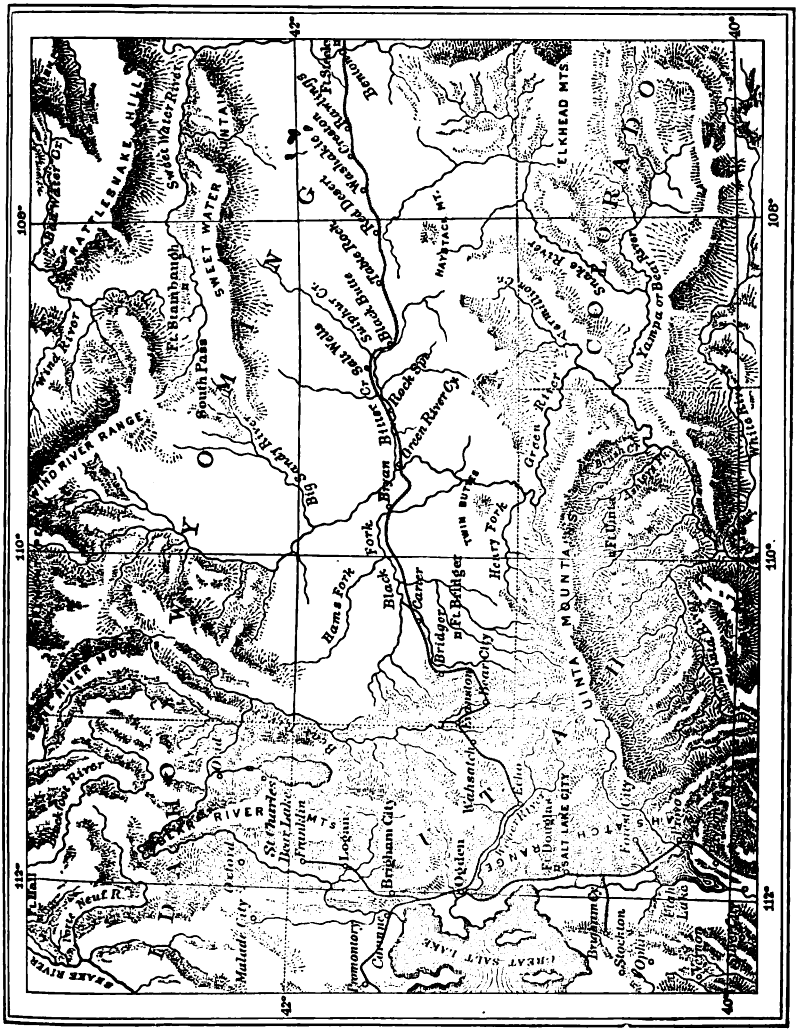
"In the following season, 1873, the author organized another large expedition, with government escort, and made a very careful examination of the regions in this same basin that remained unexplored. One of the specimens of special importance thus secured was the type of *Dinoceras laticeps*, with the skull and lower jaw nearly complete. Many other individuals of the *Dinocerata* were also discovered, and the abundant material then collected was sufficient to clear up most of the doubtful points in this group.

"The research was continued systematically during the next season, also, 1874, and again in 1875, with good results. Since then, various small parties, at different times, have been equipped and sent out by the author to collect in this basin; and, finally, during the entire season of 1882, the work was vigorously prosecuted under the direction of the author, and, from July of that year, under the auspices of the United States Geological Survey.

"The specimens thus brought together by all these various expeditions and parties are now in the museum of Yale College, and represent more than two hundred individuals of the *Dinocerata* alone. * * * * The present volume is based on this material, amply sufficient, it is believed, to illustrate all the more important parts of the structure of this remarkable group.

"The remaining material of the *Dinocerata*, now known, consists of a few specimens collected by Dr. Leidy in 1872, including the type of the genus *Uintatherium;* various remains secured in the same year by Prof. Cope, to which he applied the names *Loxolophodon* and *Eobasileus*, with a later acquisition called *Bathyopsis;* and a number of specimens more recently obtained by parties from Princeton College. Although these remains show few, if any, characters of the *Dinocerata* not better represented in the larger collection of the Yale Museum, full references to the more important specimens, in most cases with illustrations, are given in the present memoir.

"The localities in which the *Dinocerata* have been found are on both sides of the Green River, and mainly south of the Union Pacific Railroad, in Wyoming. Of two hundred individuals in the Yale Museum, about equal numbers were found east and west of this river, the distance between the extreme localities in this direction being more than one hundred miles. The map below covers this region.



MAP SHOWING REGION OF DINOCERAS BEDS.

"The *Dinocerata* have hitherto been found in a well marked geological horizon of the middle Eocene.

"The *Dinocerata* form a well marked order in the great group of *Ungulata*. In some of their characters, they resemble the Artiodactyls (*Paraxonia*); in others they are like the Perissodactyls (*Mesaxonia*); and in others still, they agree with the Proboscidians. The points of similarity, however, are in most cases general characters, which point back to an earlier, primitive ungulate, rather than indicate a near affinity with existing forms of these groups.

"The *Dinocerata*, so far as now definitely known, may be placed in three genera, *Dinoceras*, Marsh, *Tinoceras*, Marsh and *Uintatherium*, Leidy. The type specimen of *Uintatherium* was discovered near the base of the series of strata containing the remains of the *Dinocerata*. *Dinoceras*, so far as known, occurs only at a higher horizon, while *Tinoceras* has been found at the highest level of all. The characters of these three genera correspond in general with their geological position. *Uintatherium* appears to be the most primitive type, and *Tinoceras* the most specialized, *Dinoceras* being an intermediate form.

"The number of species of the known *Dinocerata* is a difficult matter to determine, especially as the limitations between species are now generally regarded as uncertain. About thirty forms, more or less distinct, are recognized in the Synopsis at the end of the volume.

THE SKULL.

"The skull of *Dinoceras mirabile* is long and narrow, the facial portion being greatly produced. The basal line, extending from the end of the premaxillaries along the palate to the lower margin of the foramen magnum, is nearly straight. The top of the skull supports three, separate, transverse pairs of osseous elevations, or horn-cores, which form its most conspicuous feature, and suggested the name of the genus. The smallest of these protuberances are situated near the extremity of the nasals; two others, much larger, arise from the maxillaries, in front of the orbits; while the largest are mainly on the parietals, and are supported by an enormous crest, which extends from near the orbits entirely around the lateral and posterior margins of the true cranium. These general characters are well shown in figure 2, which represents the skull of the type specimen.

"There are no upper incisors, but the canines in the male are enormously developed, forming sharp, trenchant, decurved tusks, which were each protected by a dependent process on the lower jaw. The premolar and molar teeth are very small.

"The orbit is large, and confluent with the temporal fossa. The latter is of great extent posteriorly, but the zygomatic arches are only moderately expanded. There is no post-orbital process.

"The nasal bones are greatly elongated, being nearly half the length of the entire skull. They project forward over the anterior nares, and overhang the premaxillaries. They are thick and massive bones, especially in front, and are united together by a nearly straight suture.

"The anterior extremity of the nasal bones, in both *Dinoceras* and *Tinoceras*, is formed of an osseous projection, pointing forward and downward, and situated in front of and below the nasal protuberances. Several specimens in the Yale Museum show that this projection is formed of two separate ossifications, each in front of its respective nasal bone.

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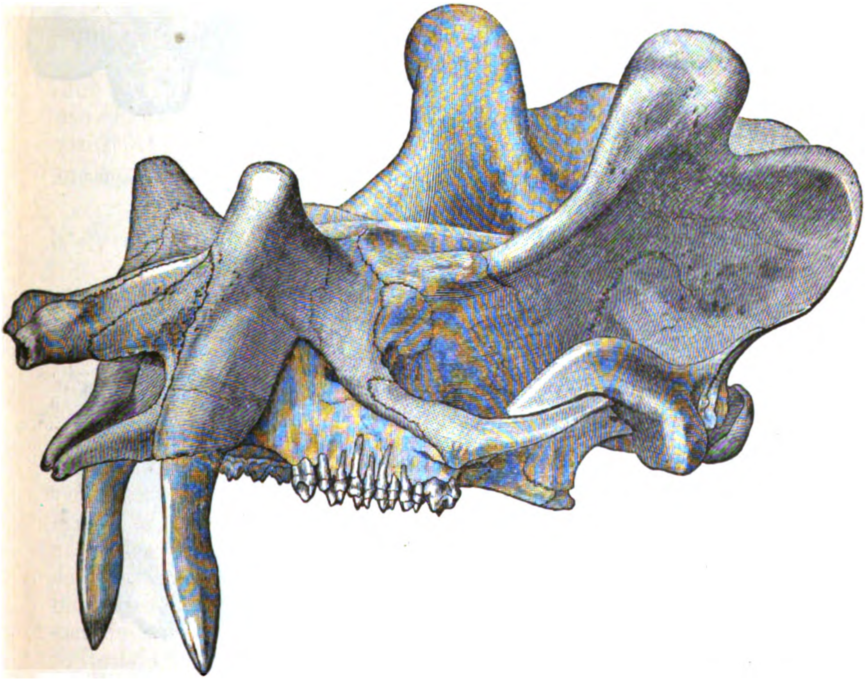
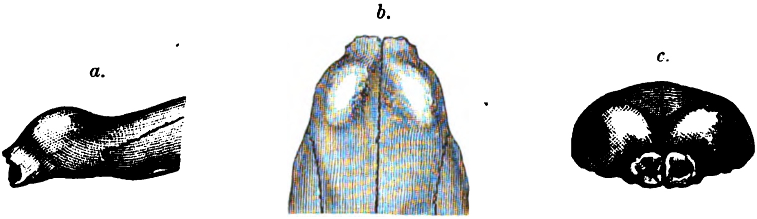


FIGURE 2.—Skull of *Dinoceras mirabile*, Marsh; seen from the left. One-sixth natural size.

"These bones are a peculiar feature in the skull of *Dinocerata*, and may be called the pre-nasal bones. In very young animals, they are unossified; in adult animals, they are distinct, as in the specimen figured; but in very old animals they become coössified with the nasals, and with each other.

3.



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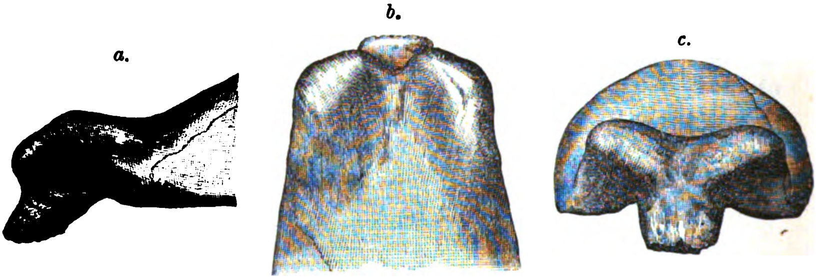
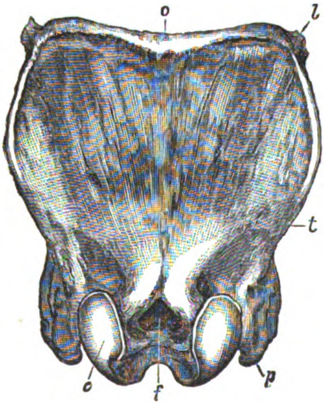


Figure 3.—Nasals of *Dinoceras mirabile*, Marsh; type specimen.
Figure 4.—Nasals of *Tinoceras annectens*, Marsh. Both figures are one-fifth natural size. *a*, side view; *b*, top view; *c*, front view.

6.



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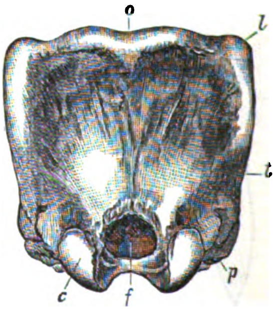
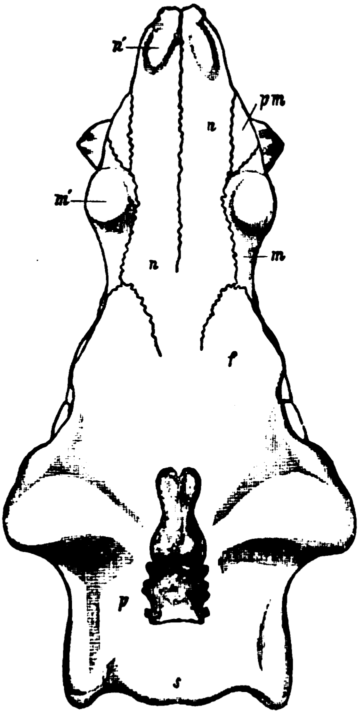


Figure 5.—Posterior surface of skull of *Dinoceras mirabile*, Marsh.
Figure 6.—Posterior surface of skull of *Tinoceras ingens*, Marsh. Both figures are one-eighth natural size. *c*, occipital condyle; *f*, foramen magnum; *l*, lateral crest; *o*, occipital crest; *p*, post-tympanic process; *t*, crest behind temporal fossa.

"The frontal bones in *Dinoceras mirabile* are shorter than the nasals. In all of the known skulls of the *Dinocerata*, the median suture uniting the two frontals is entirely obliterated. The suture joining them with the nasals in front, and with the maxillaries on the side, is distinct in the type of *Dinoceras*.

7.



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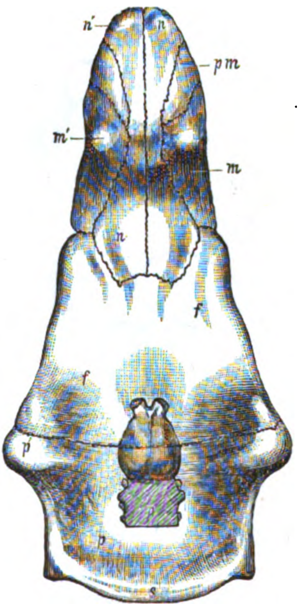


FIGURE 7.—Skull of *Dinoceras mirabile*, Marsh; with brain-cast in natural position; seen from above.

FIGURE 8.—The same view of a young specimen of *Dinoceras distans*, Marsh. Both figures are one-eighth natural size. *f*, frontal bone; *m*, maxillary bone; *m'*, maxillary protuberance; *n*, nasal bone; *n'*, nasal protuberance; *p*, parietal bone; *p'*, parietal protuberance; *pm*, premaxillary bone; *s*, supra-occipital crest.

"The maxillary bones form a large portion of the lateral surface of the skull. They contain all the teeth, except those of the lower jaw, and also expand into the large median pair of osseous elevations, or horn-cores.

"In one young specimen, the fronto-parietal suture is still open, and passes in a nearly straight line across the top of the cranium just in front of the summit of the cerebral hemispheres. It also divides the posterior elevations, or horn-cores, so as to leave the anterior part of them on the frontals, and the posterior and highest portion on the parietals.

"In all of the crania of the *Dinocerata* examined, the parietal bones are firmly united to each other on the medial line, and with the supra-occipital behind. * * * * On the sides of the cranium, the parietals form the upper portion of the large temporal fossæ.

9.

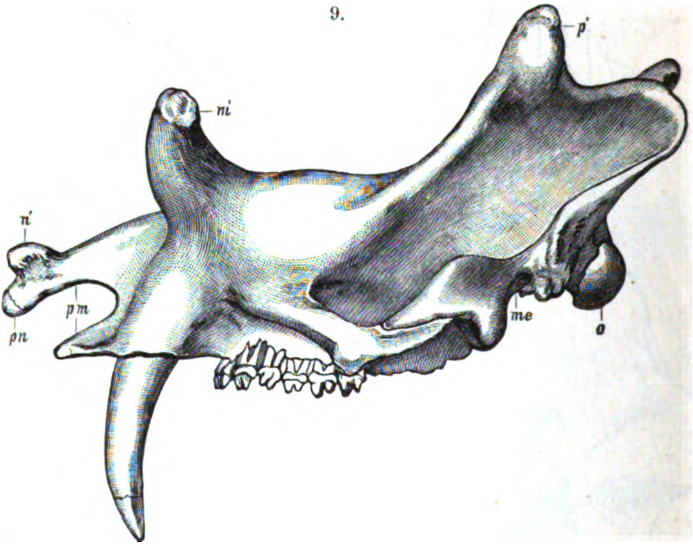
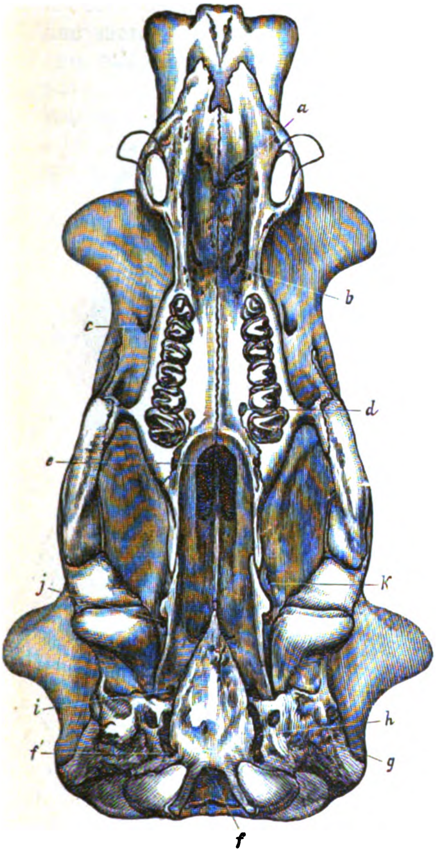


FIGURE 9.—Side view of skull of *Tinoceras pugnax*, Marsh. One-eighth natural size. *m′*, maxillary protuberance; *me*, external auditory meatus; *n′*, nasal protuberance; *o*, occipital condyle; *p′*, parietal protuberance; *pm*, premaxillary bone; *pn*, prenasal ossicle.

"The occipital region in all the known *Dinocerata* is large, elevated, and sub-quadrate in outline. It varies much in shape and size in the different genera and species, and two of the principal forms are represented in the figures below.

"The malar bone completes the anterior portion of the zygomatic arch, extending to the front of the orbit. The suture uniting the malar with the maxillary remains distinct till adult life, and may usually be traced, even in old animals. This forward extension of the malar bône is a general ungulate character, and quite different from what is seen in the Proboscidians, where the malar forms the middle portion only of the zygomatic arch.

10.



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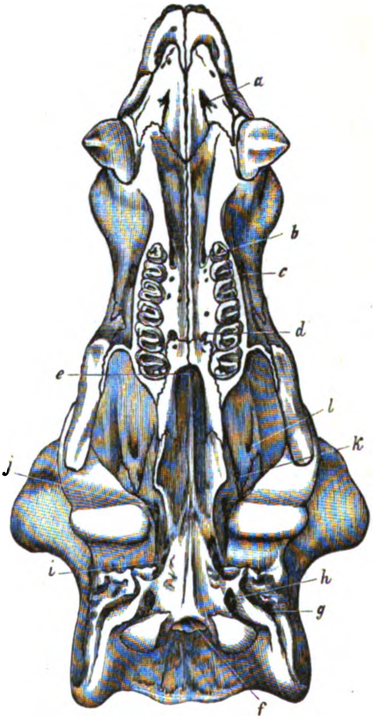
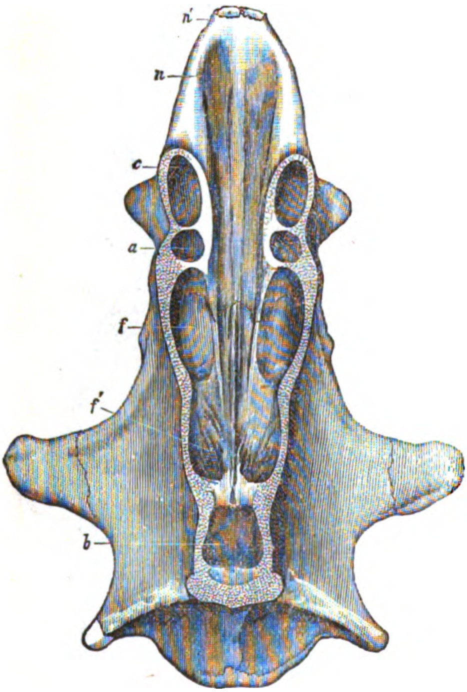


FIGURE 10.—Skull of *Tinoceras ingens*, Marsh; seen from below.
FIGURE 11.—Skull of *Dinoceras mirabile*, Marsh; seen from below. Both figures are one-eighth natural size. *a*, anterior palatine foramen; *b*, palato-maxillary foramen; *c*, antorbital foramen; *d*, posterior palatine foramen; *e*, posterior nares; *f*, foramen magnum; *f'*, occipital foramen; *g*, stylo-mastoid foramen; *h*, foramen lacerum posterius; *i*, vascular foramen in basisphenoid; *j*, posterior opening of alisphenoid canal; *k*, anterior opening of alisphenoid canal; *l*, optic foramen.

"The lachrymal is large, and forms the anterior border of the orbit. It is perforated by a large foramen. In *Dinoceras mirabile*, this is oval in outline, with the apex above. The base of the lachrymal is excavated for the posterior opening of the large antorbital foramen.

"The large canine tusk is entirely enclosed in the maxillary, and, in the genus *Dinoceras*, its root extends upward into the base of the maxillary horn-core. In all known *Dinocerata*, there is a diastema between the upper canine and the premolars.

12.



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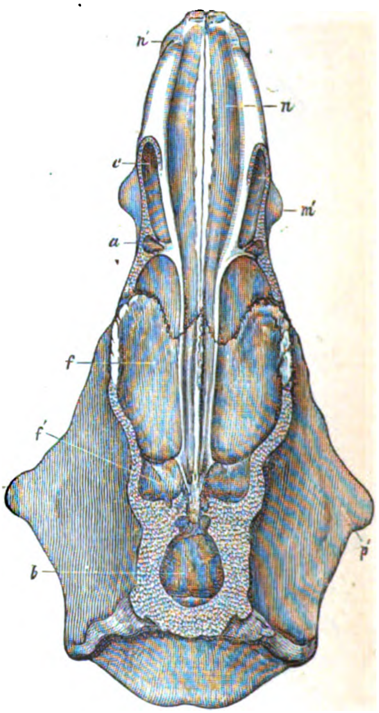


FIGURE 12.—Horizontal section of skull of *Tinoceras crassifrons*, Marsh.
FIGURE 13.—Horizontal section of skull of *Dinoceras laticeps*, Marsh; (female). Both figures are one eighth natural size. *a*, cavity behind base of canine tooth; *b*, brain-cavity; *c*, alveole of canine tooth; *f*, anterior olfactory chamber; *f'*, posterior olfactory chamber; *m'*, maxillary protuberance; *n*, nasal bones; *n'*, nasal protuberance; *p'*, parietal protuberance.

"The premaxillary bones are edentulous, and, even in young specimens, contain no teeth. * * * The premaxillaries vary much in form in the different genera and species of *Dinocerata*. Two of the principal forms are shown in figures 10 and 11."

The palate is very narrow, and much excavated, especially in front. The bony palate extends back as far as the last upper molar, and, in some specimens, beyond. It is deeply excavated on each side in the region of the diastema, and near the posterior part of each excavation on either side is situated a large foramen, which may be called the palato-maxillary foramen.

"In the type of *Dinoceras*, the palatine fossa of the posterior nares is roofed over, so that the passage from the palate into the large nasal cavities above leads forward and upward, as shown indistinctly in figure 11. In *Tinoceras ingens* and *Tinoceras pugnax*, the roof of this fossa is excavated in front by a pair of oval apertures, and, through these, the posterior nares open directly upward, as represented in figure 10.

14.

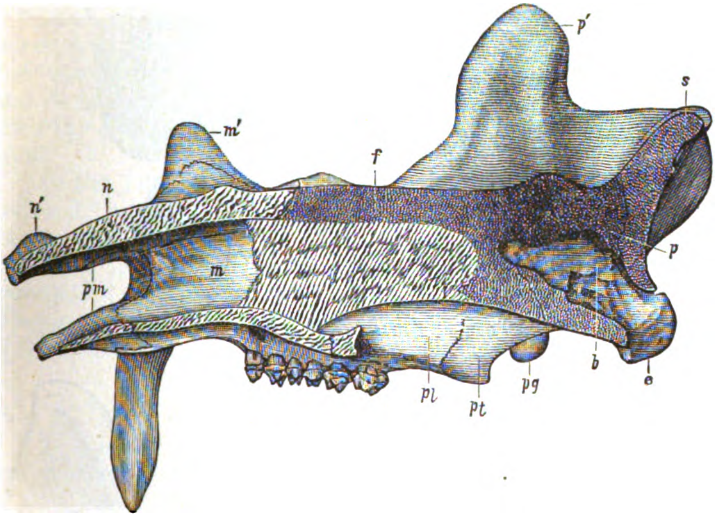
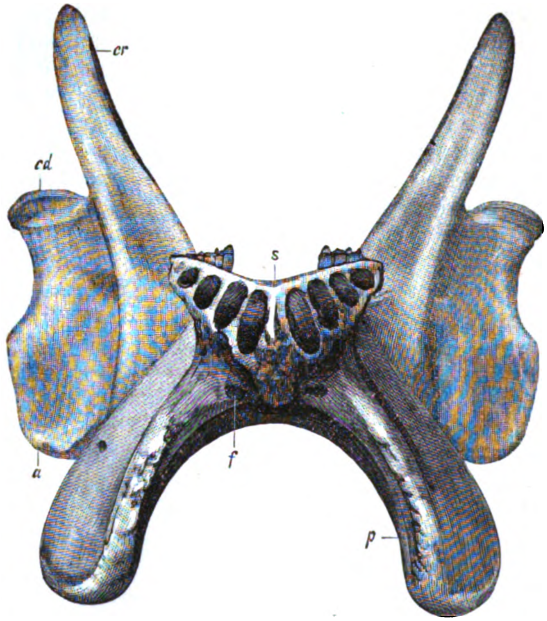


FIGURE 14.—Vertical median longitudinal section of skull of *Dinoceras mirabile*, Marsh. One-eighth natural size. *b*, brain-cavity; *f*, frontal bone; *m*, maxillary bone; *m'*, maxillary protuberance; *n*, nasal bone; *n'*, nasal protuberance; *o*, occipital condyle; *p*, parietal bone; *p'*. parietal protuberance; *pg*, post-glenoid process; *pl*, palatine bone; *pm*, premaxillary bone; *pt*, pterygoid bone; *s*, supra-occipital crest.

The Lower Jaw.

"The lower jaw in *Dinoceras* is as remarkable as the skull. Its most peculiar feature in the male is a massive decurved process on each ramus, extending downward and outward. These long, pendent processes were apparently to protect the upper canine tusks, which would otherwise be very liable to be broken. * * * * In the female, this process is much reduced in size, but is quite sufficient to protect the diminutive tusk which overlaps it.

15.



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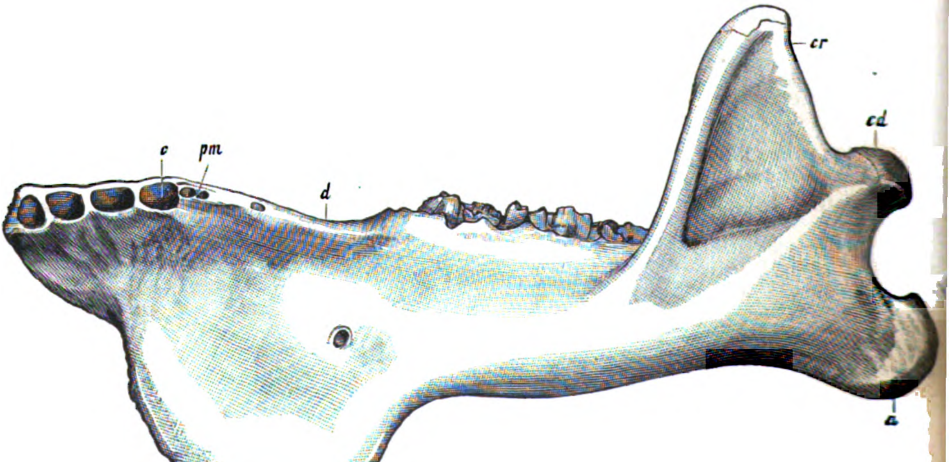


Figure 15.—Lower jaw of *Dinoceras laticeps*, Marsh; front view.

Figure 16.—Lower jaw of *Uintatherium segne*, Marsh; seen from the left. Both figures are one-fourth natural size. *a*, angle; *c*, canine; *cr*, coronoid process; *cd*, condyle; *d*, diastema; *f*, anterior foramen; *p*, process for protection of tusk; *pm*, premolar.

"Another remarkable feature in the lower jaw of the *Dinocerata* is the posterior direction of the condyles, hitherto unknown in Ungulates.

"In the genus *Dinoceras*, there are three incisor teeth, and a small incisiform canine on each side, forming a continuous series at the front extremity of the lower jaw. These are all of moderate size, and inclined well forward, as in the ruminant mammals. Behind this series, and immediately over the dependent process, is a long diastema. Further back, there are three premolars, and three molars, forming together a close series. This is the dentition, essentially, in the lower jaw of both *Dinoceras* and *Tinoceras*.

"In the genus *Tinoceras*, the same general characters of the lower jaws are seen. In the male, the pendent process is large and elongate, but less massive than in the genus *Dinoceras*, and its lower outline less regularly rounded. This corresponds with the position of the large upper canine tusk, which it protects.

"In the female of *Tinoceras*, the pendent process is much reduced, its size in all cases corresponding to the size of the canine tusk above.

"That the same relation in size between the tusk and process below it, holds equally in both the genera *Dinoceras* and *Tinoceras*, is conclusively shown by various specimens in the Yale Museum.

THE TEETH.

"The teeth of the *Dinocerata* constitute one of their most interesting features.

"In the genus *Dinoceras*, the dentition is represented by the following formula:

$$\text{Incisors } \frac{0}{3}, \text{ canines } \frac{1}{1}, \text{ premolars } \frac{3}{3}, \text{ molars } \frac{3}{3} = 34.$$

"So far as now known, the same formula applies equally well to the genus *Tinoceras*.

"In *Uintatherium*, the dentition is apparently as follows:

$$\text{Incisors } \frac{0}{3}, \text{ canines } \frac{1}{1}, \text{ premolars } \frac{3}{4}, \text{ molars } \frac{3}{3} = 36.$$

"In none of the *Dinocerata* have any upper incisors been found, even in the youngest specimens. The premaxillary bones appear to be entirely edentulous.

17.

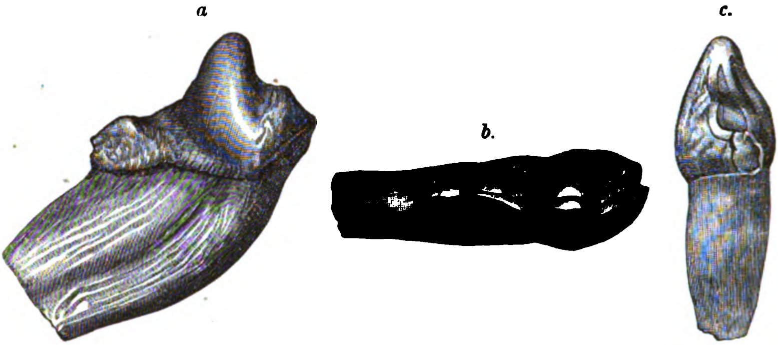
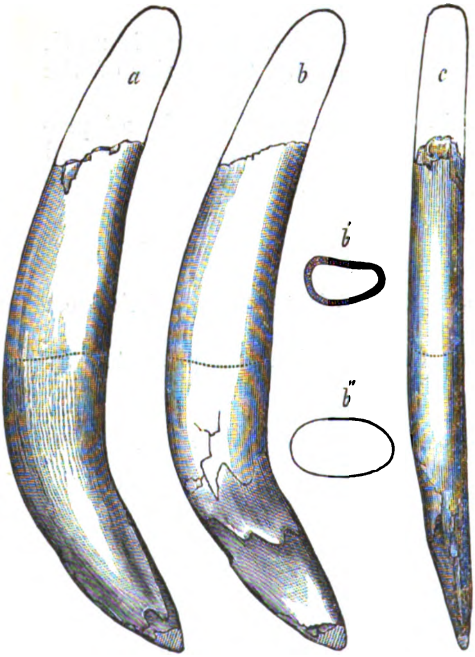


Figure 17.—Incisor of *Dinoceras mirabile*, Marsh. Natural size. *a*, side view; *b*, top view; *c*, antero-posterior view.

18.



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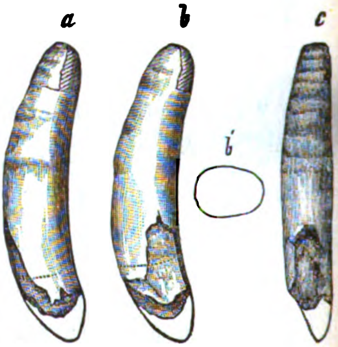
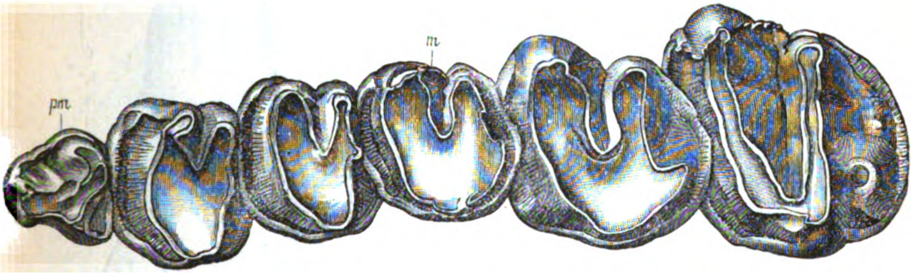


Figure 18.—Upper canine of *Dinoceras laticeps*, Marsh; (male).
Figure 19.—Upper canine of *Dinoceras laticeps* (female). Both figures are one-fourth natural size. *a*, lateral view, showing outer surface; *b*, inner surface; *b' b''*, sections; *c*, front view.

"In the lower jaw of all the known *Dinocerata*, there are three well developed incisors on each side. They are inserted, each by a single root, and are procumbent, all directed well forward.

"The superior canines of *Dinoceras* are long, decurved, trenchant tusks. The crown is covered with enamel, and the root extends upward into the base of the maxillary protuberance, or horn-core. When the animal is young, these tusks grow from a persistent pulp, but, in old age, the cavity becomes nearly closed. In the male, these tusks are large and powerful, and extend downward nearly or quite to the extremity of the pendent process of the lower jaw.

20.



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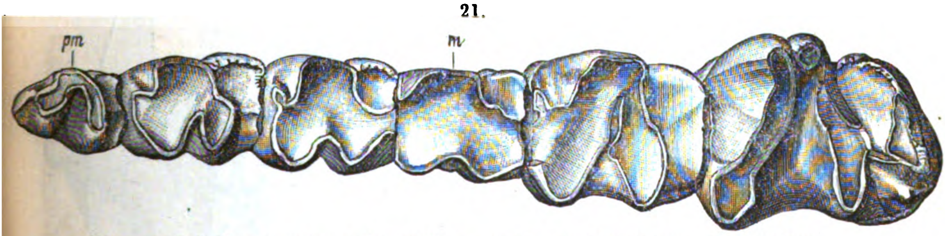


FIGURE 20.—Upper molar series of *Tinoceras stenops*, Marsh; seen from below.
FIGURE 21.—Lower molar series of same specimen; seen from above. Both figures are three-fourths natural size. *m*, molar; *pm*, premolar.

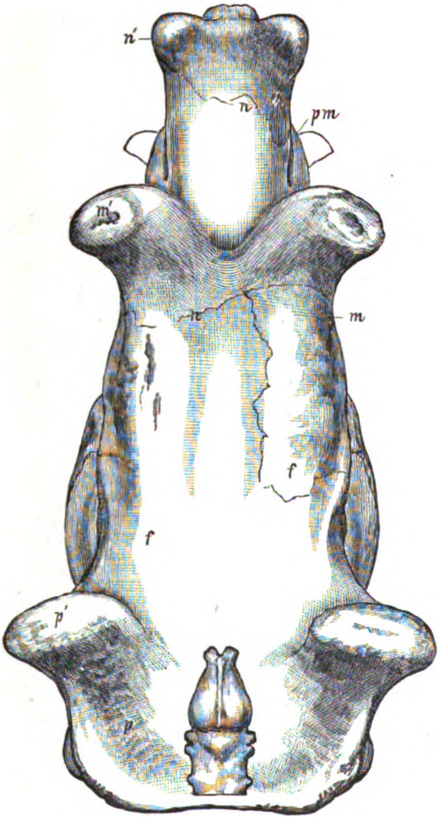
"In the female of *Dinoceras*, the upper canines are small and slender, and protrude but little below the jaw."

The crowns of the upper premolar and molar teeth in *Dinoceras*, and, in fact, in all of the known *Dinocerata*, are remarkably short, with the roots well developed, forming a true brachyodont dentition, as in all early Tertiary ungulates.

"In each ramus of the lower jaw of *Dinoceras*, there is a close series of six teeth, three of which are premolars, and three true molars. These are all inserted each by two roots This is also true of the genus *Tinoceras*.

"The molar teeth in *Dinocerata* appear to resemble more closely the corresponding teeth in the genus *Coryphodon* than those of any other animal. The general dentition, however, is quite distinct. *Coryphodon* has well developed upper incisors, and a medium sized upper canine, thus differing widely in these features from the *Dinocerata*.

22.



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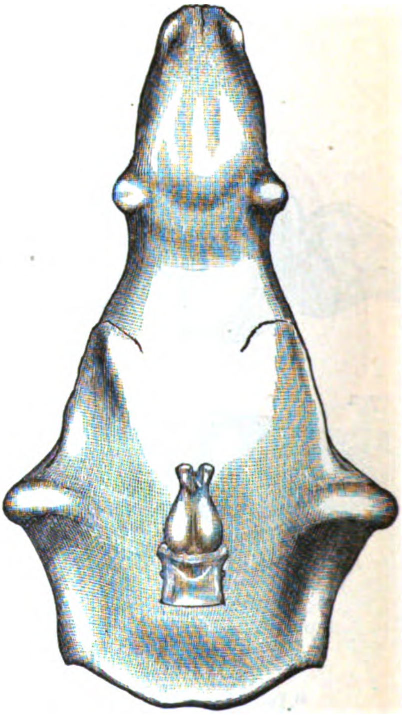


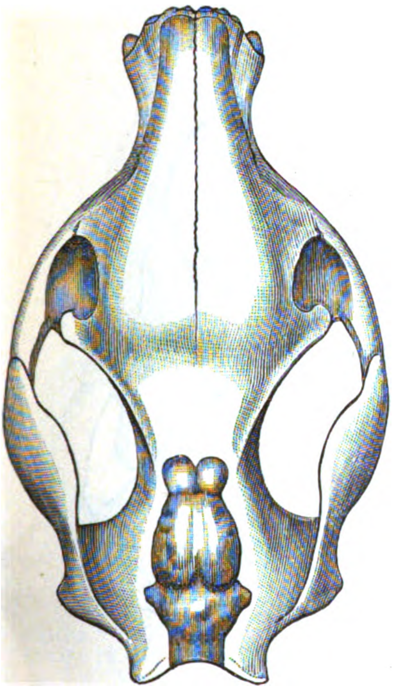
FIGURE 22.—Skull of *Tinoceras ingens*, Marsh; with brain-cast in position; seen from above.

FIGURE 23.—Skull of *Dinoceras laticeps*, female; with brain-cast in position. Both figures are one-eighth natural size. *f*, frontal bone; *m*, maxillary bone; *m'*, maxillary protuberance; *n*, nasal bone; *n'*, nasal protuberance; *p*, parietal bone; *p'*, parietal protuberance; *pm*, premaxillary bone.

THE BRAIN.

"The brain of the *Dinocerata* is one of the most peculiar features of the group. It is especially remarkable for its diminutive size. It was proportionately smaller than in any other known mammal, recent or fossil, and even less than in some reptiles. It was, indeed, the most reptilian brain in any known mammal. In *Dinoceras mirabile*, the entire brain was actually so diminutive that it could apparently have been drawn through the neural canal of all the pre-sacral vertebræ, certainly through the cervicals and the lumbars.

24.



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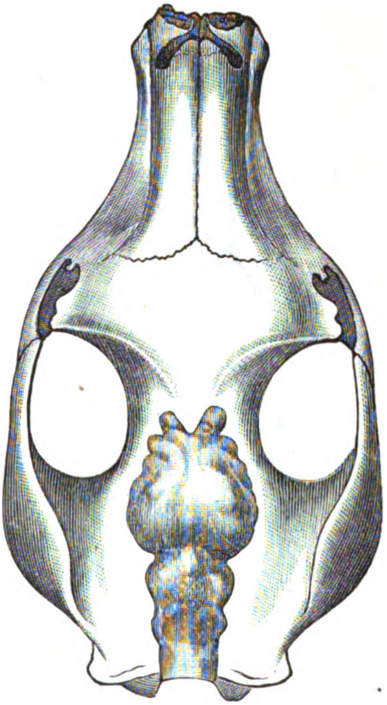


Figure 24.—Skull of *Limnohyus robustus*, Marsh. Middle Eocene.
Figure 25.—Skull of *Amynodon advenus*, Marsh. Upper Eocene.

"The size of the entire brain, as compared with that of the cranium, is shown in the accompanying cuts, figures 7, 8, and 23. The size of the brain cavity, and its position in the skull in the genus *Tinoceras*, also, is represented in figure 22.

"The most striking feature in the brain cavity itself is the relatively small size of the cerebral fossa, this being but little larger than the cerebellar portion.

"The cerebral hemispheres did not extend at all over the cerebellum or the olfactory lobes. The latter were large, and continued well forward.

"The nerves passing off from the brain were large, and can be made out with reasonable certainty. The olfactory lobes were separated in front by an osseous septum, the position of which is shown distinctly in figure 22.

"In the genus *Tinoceras*, the brain was similar in its general characters to that of *Dinoceras*, but appears to have been somewhat more highly developed. The hemispheres were more elongate, and the olfactory lobes relatively smaller.

26.

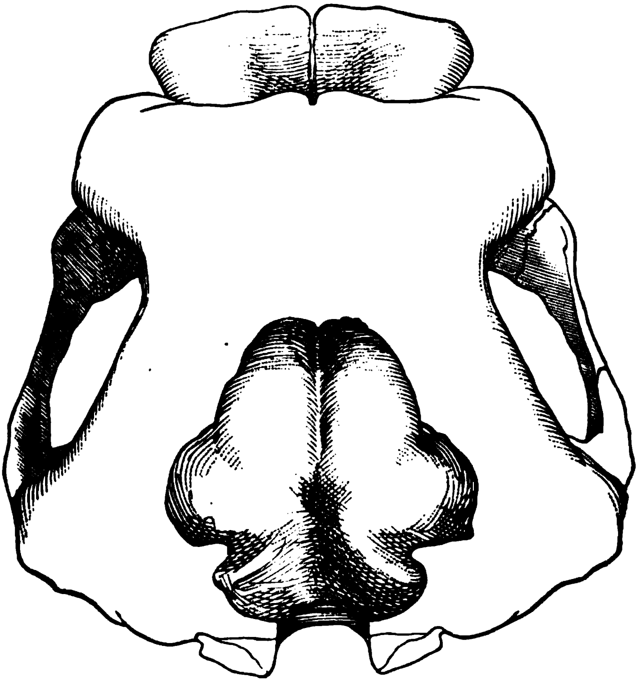


FIGURE 26.—Skull of *Mastodon Americanus*, Cuvier. Pliocene.

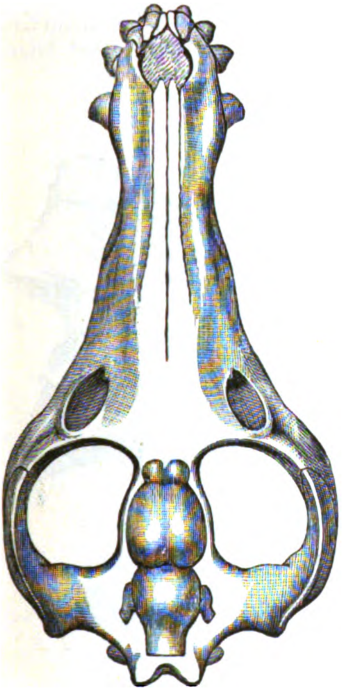
BRAIN GROWTH.

"The *Dinocerata* are, by far, the largest of all known Eocene animals, and that they have, also, a very diminutive brain is a noteworthy fact, which attracted the author's attention soon after their discovery.

"The comparison of the brain in this group with that of other mammals from the same formation soon showed that the *Dinocerata* although most remarkable in this respect, were not alone in diminutive capacity of brain power. A more extended comparison led to the fact that all the early Tertiary mammals had very small brains.

"The results of this investigation were embodied by the author in a general law of brain-growth in the extinct mammals throughout Tertiary time. This law, briefly stated, was as follows:

27.



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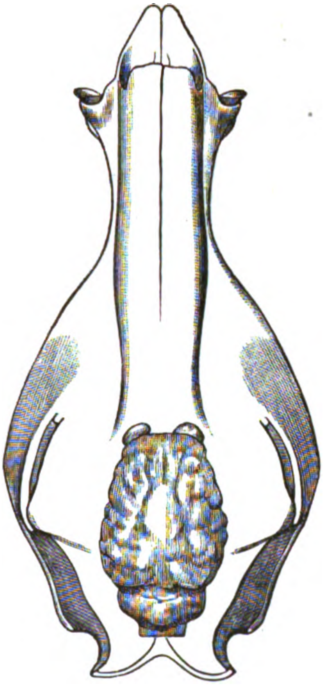

FIGURE 27.—Skull of *Elotherium crassum*, Marsh. Miocene.
FIGURE 28.—Skull of *Platygonus compressus*, LeConte. Pliocene.

1. All Tertiary mammals had small brains.
2. There was a gradual increase in the size of the brain during this period.
3. This increase was confined mainly to the cerebral hemispheres, or higher portion of the brain.
4. In some groups, the convolutions of the brain have gradually become more complex.
5. In some, the cerebellum and the olfactory lobes have even diminished in size.
6. There is some evidence that the same general law of brain growth holds good for Birds and Reptiles from the Cretaceous to the present time.*

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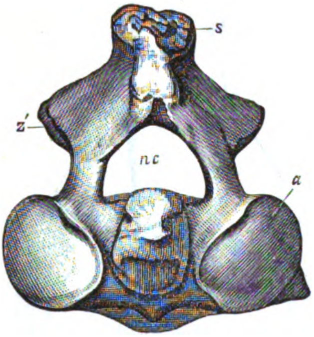
* This Journal, vol. viii, p. 66, July, 1874; and vol. xii, p. 61, July, 1876; also Odontornithes, p. 10, 1880.

"The author has since continued this line of investigation, and has ascertained that the same general law of brain growth is true for Birds and Reptiles, from the Jurassic to the present time."

The small size of the brain in early Tertiary mammals will be indicated by an examination of the *Dinocerata* skulls, with the brain in position, shown in figures 22, 23. This is further shown by figures 24–28, which represent the skull and brain-cast of various Tertiary Mammals.

29.



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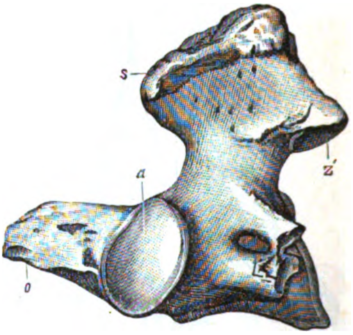

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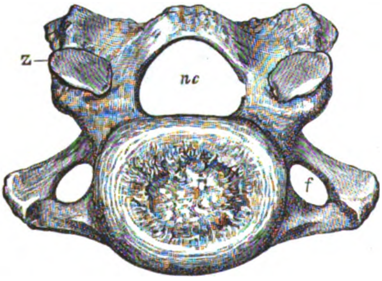

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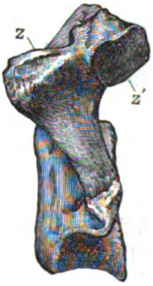


Figure 29.—Axis of *Dinoceras mirabile*, Marsh; front view.
Figure 30.—The same vertebra; side view.
Figure 31.—Cervical vertebra of *Tinoceras grande.* Marsh; front view.
Figure 32.—The same vertebra; side view. All the figures are one-fourth natural size. *a*, face for atlas; *f*, lateral foramen; *n c*, neural canal; *o*, odontoid process; *s*, neural spine; *z*, anterior zygapophysis; *z'*, posterior zygapophysis.

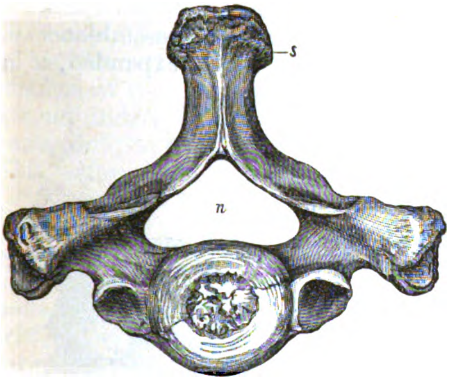
The Vertebræ.

"The cervical vertebræ of the *Dinocerata*, in their main characters, resemble those of the Proboscidians. The atlas and axis are somewhat similar to those of the elephant. The rest of the cervicals are proportionally longer. The entire neck was about one-third longer than in the elephant, thus rendering a proboscis unnecessary, as the head could readily reach the ground.

"All the presacral vertebræ, behind the atlas and axis, have the articular faces of the centra nearly flat, as in the typical Proboscidians.

"The trunk vertebræ in the *Dinocerata* are proportionally longer than those in the cervical region. The articular faces of the centra are likewise nearly flat, the most of them being distinctly concave.

33.



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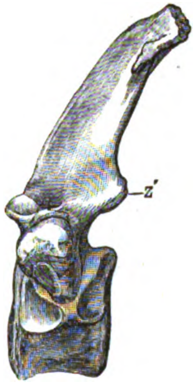


FIGURE 33.—Second dorsal vertebra of *Dinoceras mirabile*, Marsh; front view.
FIGURE 34.—The same vertebra; side view. *n*, neural canal; *s*, neural spine; *z'*, posterior zygapohysis.

THE FORE LIMBS.

"The limb bones in the *Dinocerata* are nearly or quite solid, and this is true of all the skeleton, a portion of the skull alone excepted.

"The fore limbs in the *Dinocerata* have a general resemblance to those of Proboscidians.

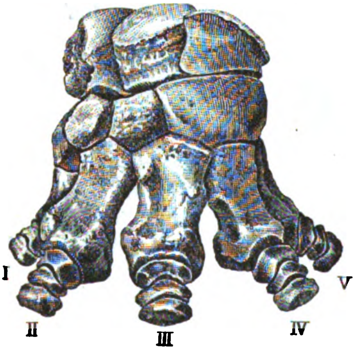
"The fore foot in all the *Dinocerata* is larger than the hind foot. The bones composing it are comparatively short and massive. There were five well-developed digits, as in Proboscidians, but the carpal bones were interlocked with the metacarpals, as in Perissodactyls. The general appearance of the fore foot in *Dinoceras mirabile* is well shown in figure 35. The hind foot is represented in figure 36. The feet were plantigrade, as in the elephant.

"There are eight separate carpal bones in the fore foot of all the *Dinocerata*, and a ninth, the central bone, may be separate in very young animals, and, in adults, either lost or consolidated with the scaphoid, or the trapezoid. * * * * The metacarpal bones in the *Dinocerata* are short and robust. * * * * The phalanges in the fore foot of the *Dinocerata* are very short, and comparatively small.

"Sternal bones are preserved in a number of individuals of the *Dinocerata* in the Yale Museum, but the entire series in any one individual has not been recovered. * * * * The most marked character of these bones in the *Dinocerata* is that they are flat and horizontal, as in the Artiodactyls, and not vertical, as in the Proboscidians, and the Perissodactyls."

The pelvis in the *Dinocerata* has a general resemblance to that of the elephant. The ilia were widely expanded, as in that animal. There are four sacral vertebræ.

35.



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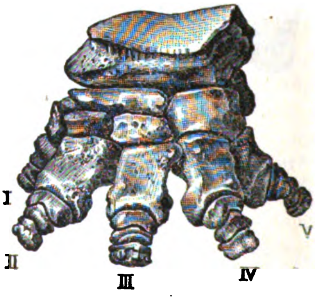

Figure 35.—Left fore foot of *Dinoceras mirabile*, Marsh.
Figure 36.—Left hind foot of the same. Both figures are one-fifth natural size.

The Hind Limbs.

"The hind limbs of the *Dinocerata* have a general resemblance to those of Proboscidians, but the bones composing them are comparatively shorter, and more robust. When the animal was standing at rest, the posterior limb formed a strong and nearly vertical column.

"The hind feet in the *Dinocerata* were considerably smaller than those in front. * * * * There were five digits, as in the Proboscidians, and the axis of the foot was through the third, or middle, digit.

"There are seven well developed tarsal bones in the *Dinocerata*, and their relative position in the hind foot is seen in figure 36. * * * * An eighth tarsal bone, the tibiale, appears to have been present.

"The astragalus in the *Dinocerata* considerably resembles that of the elephant, the bone being, as in that animal, very short, along the axis of the leg and foot.

"The calcaneum is short, and comparatively more robust than in the elephant. As in that animal, it is strongly tuberculated below, where, during life, it doubtless supported a thick pad, resting on the ground."

RESTORATIONS.

From Chapter XIII, on the restorations of *Dinoceras* and *Tinoceras*, the following extracts are selected:

"In the restoration of *Dinoceras mirabile* on Plate LV, the remains of the type specimen of the species, a fully adult, but not old individual, have been used for the more important parts, and the remaining portions taken from other individuals. This restoration is one-eighth natural size.

"The animal is represented as walking, and the position of the head, and the feet, has been chosen to show, to the best advantage, these portions of the skeleton as they were in life. In this restoration, only those portions are shaded which are represented by actual specimens in the Yale Museum. The parts in outline are wanting, or are so poorly preserved that only their main features can be given with accuracy.

"In the restoration of *Tinoceras ingens*, Plate LVI, the animal is represented one-sixth natural size, and standing at rest. The position here chosen shows the massive and majestic form of one of the largest individuals of this remarkable group." A reduced copy of this restoration is given in figure 37.

"In comparing *Dinoceras*, as here restored, with some of the largest ungulate mammals of the present day, a certain resemblance to the rhinoceros on the one hand, and to the elephant on the other, will naturally suggest itself. In size and proportions, *Dinoceras* was intermediate between these two existing animals, and, in various points of its structure, it resembled the one quite as much as the other. In still other features, *Dinoceras* resembled the hippopotamus.

"In its stature and movements, *Dinoceras* probably resembled the elephant as much as any other existing form. Its remarkable skull, longer neck, and more bent fore limbs, gave it, however, a very different appearance from any known Proboscidian. The high protuberances, or horn-cores, on the head, the long, trenchant, canine tusks, and the peculiar lower jaw modified for their protection, are features seen together only in this group.

"The neck was long enough to permit the head to reach the ground, and hence a proboscis was quite unnecessary. The horizontal narial opening, the long overhanging nasal bones, and the well developed turbinal bones, are likewise proof positive against the presence of such an organ. There is some evidence of a thick flexible lip, resembling, perhaps, that of the existing rhinoceros.

"The remarkably small brain, and the heavy massive limbs, indicate a dull, slow-moving animal, little fitted to withstand marked changes in its environment, and hence it did not survive the alterations of climate with which the Eocene period closed.

"Both the animals chosen for these two restorations were evidently males, as shown by the lofty protuberances, or horn-cores, on the skull, and the powerful canine tusks. In the females, these parts are but feebly developed, as shown in the specimens described in the preceding chapters. The individuals here restored were certainly thrice-armed, and well fitted to protect themselves, and their weaker associates, from any of their Eocene enemies.

"The exact form and nature of the offensive weapons which surmounted the head of the *Dinocerata* cannot, at present, be determined with certainty. That the paired osseous elevations seen on the skull in all the known species of this group did not support the kind of horns seen in the typical Ruminants is evident from their external surface, which lacks the vascular grooves so distinct on the horn-cores of those animals.

"Possibly, the *Dinocerata* may have been armed with horns similar to those seen in the American antelope (*Antilocapra*), since, in this animal, the horn-cores are even smoother than in the order here described. More probably, however, the bony protuberances on the skull were covered with bosses of thick skin, hard enough to be effective in combat. Evidence of such contests has apparently been recorded in the injuries to the horn-cores of some individuals, received during life. None of the covering of these elevations, or horn-cores, has, of course, been preserved; yet a fortunate discovery may, perhaps, reveal their nature by the form of a natural cast, as the eye-ball of the Oreodon is sometimes thus clearly indicated in the fine Miocene matrix which occasionally envelops these animals.

"The short robust feet of the *Dinocerata* were doubtless covered below with a thick pad, as in the elephant, since the whole under side of the foot clearly indicates such a protection. No portion of this covering has been preserved in any of the known specimens, and no foot-prints indicating its form, have been discovered, in the Eocene deposits in which the *Dinocerata* were entombed."

The size of *Tinoceras ingens*, as he stood in the flesh, was about twelve feet in length, or sixteen measured from the nose to the end of the tail. The height to the top of the back was about six and one-half feet, and the width across the hips about five feet. The weight, judging from that of existing mammals, was about six thousand pounds.

"*Dinoceras mirabile* was about one-fifth smaller. The neck was longer, but, in other respects, the proportions were nearly the same."

37.

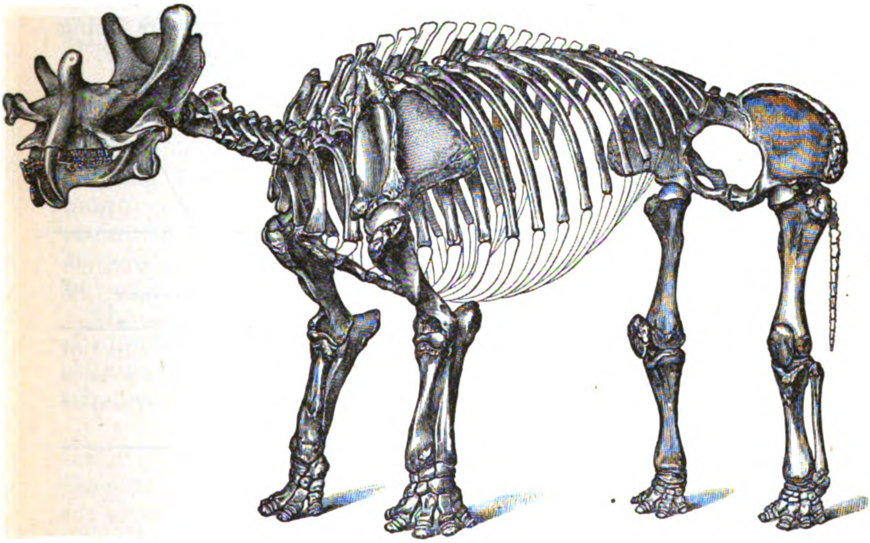

Figure 37.—Restoration of *Tinoceras ingens*, Marsh. One-thirtieth natural size.

The concluding chapter, XIV, contains a full discussion of the genealogy of ungulate mammals in general, and the relations of the *Dinocerata* to other groups. We quote as follows:

"Our present knowledge of the Mammalia, living and extinct, clearly indicates that they must go back at least to the Permian. The generalized mammal of that period, or of still earlier time, was probably quite small, and, in many respects, like an Insectivor. This primitive type would naturally possess all the general characters found in later forms in the various orders of mammals.

"This generalized mammal would belong to the group named *Hypotheria* by Huxley, who has laid a sure foundation for investigation in this line of research.

GENEALOGY OF UNGULATES.

"From this primitive type of mammal, a special line apparently led off through the Triassic and Jurassic to the Cretaceous, where it formed a well-marked group, which may be called the *Protungulata*, the probable ancestors of all succeeding ungulate mammals.

"From this generalized ungulate, the skeleton of which we now know almost as well, apparently, as if we had it before us, a direct line would appear to have continued up to the present day, and be represented by the living Hyrax. Several divergent lines passed off probably from the same stem, and three of these have continued to the present time, the survivors being the *Proboscidia*, the *Artiodactyla*, and the *Perissodactyla*.

38.

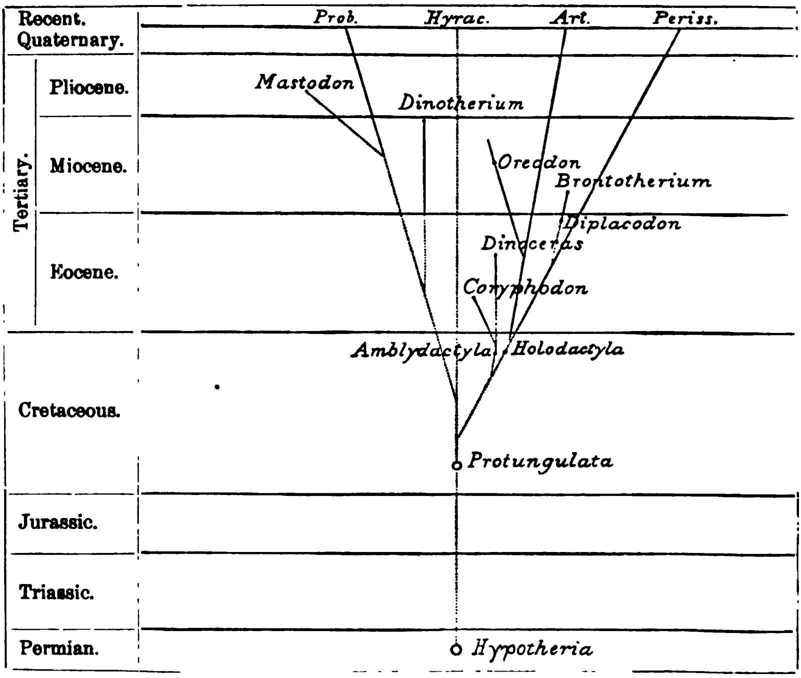

FIGURE 38.—Diagram to illustrate the genealogy of Ungulate Mammals.

"Another order, also, which may be termed the *Amblydactyla*, passed off apparently from the main ungulate stem in the Cretaceous, and became extinct in the Eocene. One branch terminated in *Coryphodon*, in the lower Eocene, and the other, represented by the *Dinocerata* here described, came to an end in the middle Eocene.

In figure 38, above, a diagram is given, which shows graphically these lines of descent, and the most probable genealogy of modern ungulates. The diagram, being on a plane, can only indicate the general position of these divergent lines.

"From this group came off, evidently in the late Cretaceous, first the *Coryphodontia*, having nearly all the above characters, and becoming extinct in the early Eocene.

"The *Dinocerata* probably branched off about the same time, and survived to the middle Eocene, thus becoming much more specialized before their extinction.

"Accepting this general view of the origin of the Ungulates, living and extinct, their classification has been outlined in the diagram on page 200.

"The attempts hitherto made to give a detailed classification of all the Mammalia, living and extinct, have signally failed, mainly because only a small part of even the extinct forms now known were included, and almost every new discovery tended to break down the definitions so systematically recorded. The time for such an exhaustive classification has not yet arrived, and all that can be safely ventured upon in the present state of knowledge is to indicate the main groups and their affinities, and await future discoveries.

"Excluding the aberrant, aquatic, Sirenians, now regarded as of ungulate ancestry, and leaving out also *Toxodon* and other little known extinct forms, the ungulate mammals may then be arranged in natural groups, as follows:

CLASS MAMMALIA.

Sub-Class MONODELPHIA.

Super-Order UNGULATA.

(1.) Order Hyracoidea.
(2.) Order Proboscidea.
(3.) Order Amblydactyla { Dinocerata. Coryphodontia.
(4.) Order Clinodactyla { Mesaxonia (Perissodactyla). Paraxonia (Artiodactyla).

"The characters found in existing mammals, and, to a great extent, in the extinct forms from the Tertiary to the present time, are clearly of two kinds; general characters, derived from ancestral forms, and special characters, acquired in adaptation to their environment. Some of the latter may be negative characters, acquired by the disuse, or loss, of parts once advantageous.

"The first series of characters are of most importance, as they indicate a genetic connection, perhaps remote, with the different groups that share them. Special characters, on the other hand, however closely they may correspond in different groups, do not necessarily indicate affinities, but may have been acquired by adaptation to peculiar surroundings, in groups quite distinct from each other.

"These facts lie at the foundation of classification, and it is only by keeping the two series of characters separate, that the true relationship between different groups of animals can be made out, and their genealogy indicated with any probability.

* * * * * *

MODIFICATION OF THE UNGULATE FOOT.

"In the true ungulate mammals, the modifications of the foot have undoubtedly taken place very nearly in the following manner:

(1.) The primitive Ungulates (*Protungulata*) must have had plantigrade, pentadactyl, feet, with the carpals and tarsals not interlocking either with the metapodial bones, or with their own adjoining series. This would give a weak foot, adapted especially to progression in soft, swampy ground.

(2.) For locomotion on dry hard ground, a stronger foot was required, and a modification soon took place, in the interlocking of the metapodials with the second row of carpals or tarsals that supported them. Examples of nearly this stage are seen in the fore feet of *Coryphodon*, and of *Dinoceras* as shown in figure 36.

(3.) A still stronger foot was produced by the further interlocking of both the first and second row of carpals and tarsals, as well as the latter row with the metapodials below. This general type of foot belongs to the *Holodactyla*, and is seen also in some of the early Perissodactyls.

During these two stages of modification, a reduction in the number of digits also took place, evidently as a result of the same causes. The first digit, being the shortest of the series, soon left the ground, as progression on dry land with the plantigrade five-toed foot began, and was gradually lost.

The four remaining digits, having to do the work of five, were strengthened by the interlocking already mentioned, and also by coming nearer together.

(4.) In the next change that took place, two kinds of reduction began. One leading to the existing perissodactyl foot, and the other, apparently later, resulting in the artiodactyl type. In the former, the axis of the foot remained in the middle of the third digit, as in the pentadactyl foot. In the latter, it shifted to the outer side of this digit, or between the third and fourth toes. An example of the former is seen in the fore foot of *Brontotherium*, while *Oreodon* shows the latter type.

The position of the axis is the distinctive feature between these two types of feet, and not the number of toes, as the names usually applied to them indicate. In this respect, the terms Artiodactyl and Perissodactyl are misleading, and hence the names *Paraxonia* and *Mesaxonia* were proposed by the author, as substitutes, to express the true axial relation.

(5.) In the further reduction of the perissodactyl foot, the fifth digit, being shorter than the remaining three, next left the ground, and gradually disappeared. Of the three remaining toes, the middle, or axial, one was the longest, and retaining its supremacy, as greater strength and speed were required, finally assumed the chief support of the foot, and the outer digits left the ground, ceased to be of use, and were lost, except as splint bones. The foot of the existing horse shows the best example of this reduction in the Perissodactyls, as it is the most specialized known in the Ungulates.

(6.) In the Artiodactyl foot, the reduction resulted in the gradual diminution of the two outer of the four remaining toes, the third and fourth doing all the work, and thus increasing in size and power. The fifth digit, for the same reasons as in the perissodactyl foot, first left the ground, and became smaller. Next, the second soon followed, and these two gradually ceased to be functional, or were lost entirely, as in some of the Artiodactyls of to-day. The foot of the goat shows this extreme reduction.

* * * * * *

EXTINCTION OF LARGE MAMMALS.

"During the Mesozoic period, all the mammals appear to have been small, and it is not probable that any of large size existed, as reptilian life then reigned supreme. With the dawn of the Tertiary, a new era began, and mammalian life first found the conditions for its full and rapid development.

"In the lower Eocene, the largest land mammal was *Coryphodon*, more than the equal, in size and power, of any of the reptiles of that time. *Dinoceras* and its allies, in the middle Eocene, were much larger, and were clearly the monarchs of the region in which they lived. In the upper Eocene, *Diplacodon*, about the size of the rhinoceros, was the largest mammal, but each of these three died out in the period in which it flourished.

"At the base of the Miocene, the huge *Brontotheridæ*, nearly as large as the elephant, suddenly appear in great numbers. They remained for a short time the dominant land animals, and then became extinct.

"The Proboscidians were the giants of the Pliocene, and hold the supremacy in size to-day, but are evidently a declining race.

"The cause of the successive disappearance of each group of these large Tertiary mammals is not difficult to find. The small brain, highly specialized characters, and huge bulk, rendered them incapable of adapting themselves to new conditions, and a change of surroundings brought extinction. The existing Proboscidians must soon disappear, for similar reasons. Smaller mammals, with larger brains, and more plastic structure, readily adapt themselves to their environment, and survive, or even send off new and vigorous lines.

"The *Dinocerata*, with their very diminutive brain, fixed characters, and massive frames, flourished as long as the conditions were especially favorable, but, with the first geological change, they perished, and left no descendants.

* * * * * * * *

Classification.

"The *Dinocerata* now known may be placed in three genera: *Dinoceras*, *Tinoceras*, and *Uintatherium*. These may be separated by characters of the skull, vertebræ, and feet. There are also indications of several intermediate forms, which may, perhaps, be found to represent sub-genera, when additional specimens in good preservation are secured for comparison. Twenty-nine species may be distinguished, mainly by the skull alone, which, at present, offers the best distinctive characters.

Sub-order DINOCERATA, Marsh.

Family Tinoceratidæ, Marsh.

Uintatherium, Leidy.	*Dinoceras*, Marsh.	*Tinoceras*, Marsh.
Teeth, thirty-six.	Teeth, thirty-four.	Teeth, thirty-four.
Lower premolars, four.	Lower premolars, three.	Lower premolars, three.
Base of canine tusk, nearly vertical.	Base of canine tusk, nearly vertical.	Base of canine tusk, horizontal.
Parietal protuberance, above post-glenoid process.	Parietal protuberance, above post-glenoid process.	Parietal protuberance, behind post-glenoid process.
Cervical vertebræ, of moderate length.	Cervical vertebræ, less elongate.	Cervical vertebræ, short.
Lunar, articulating with trapezoid?	Lunar, articulating with trapezoid.	Lunar, not articulating with trapezoid.

"These three genera clearly represent three stages of development of the *Dinocerata*, and these stages correspond to the successive horizons of the middle Eocene in which the remains of these animals were entombed. *Uintatherium*, the most generalized type, is found at the lowest level; *Dinoceras* is from a somewhat higher stratum; and *Tinoceras*, the most specialized of all, occurs in the latest deposits."

In the Synopsis which follows this chapter, a systematic list of all the species of the *Dinocerata* is given in detail, and the volume closes with a Bibliography of the important literature.

L. P. B.

Art. XXVII.—*On Taconic Rocks and Stratigraphy, with a Geological map of the Taconic region* (Plate II); by James D. Dana.

In my papers of 1873 and 1877,* on the Limestone, Schists and Quartzyte of the Taconic region, I present evidence (1) from the facts illustrated by various stratigraphical sections, (2) from the continuity and common features of the conformable series of these rocks from north to south, and (3) from fossils existing (as made known by others) in some of the beds, that these rocks are (A) of one system; and (B) of Lower Silurian age; and (C) have the Taconic schists as the upper member of the series.

In my work I made no attempt to map the region, since the point in view was stratigraphical, with special reference to the "lithological canon," and its illustration did not seem to demand it. The evidence presented has, been questioned on the ground (1) that the continuity of the system is not clearly established, and (2) that the relation of the quartzyte to the other rocks is not fully worked out. In order to remove as far as may be, the uncertainties on these points, I began over three years since, a new study of the region, with reference to its stratigraphy and geological structure, and the details required for the construction of a geological map. Two papers in the last volume of this Journal contain results derived from this recent investigation. In the paper here begun I present the facts gathered bearing on the constitution and stratigraphical relations of the rocks, and on their distribution and geographical relations, and illustrate the subjects by means of the prepared map as well as by diagrams.

The region is that of the Taconic rocks as first laid down by Professor Ebenezer Emmons—these rocks including according to his original enunciation of his system: (1) The Taconic schists of the Taconic range and of the subordinate ridges within the adjoining limestone area; (2) the limestone formations on the east and west sides of the Taconic Range; and (3) the quartzyte adjoining or within the limestone area.

The investigations have extended over Berkshire county in Massachusetts, Salisbury and Canaan in Connecticut, and less completely over Pownal and Bennington, Vermont, and the adjoining eastern border of the State of New York. This is not the whole of the true Taconic region, as it continues northward to central Vermont; but it comprises the portion that was the special subject of Professor Emmons's earlier investigations.

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* This Journal, III, v, vi, 1873, and xiii, xiv, 1877.

In this *first part* of my paper I treat of the southern portion of the above-mentioned area, comprising the towns of Salisbury and Canaan in Connecticut and of Mt. Washington, Sheffield and New Marlborough in Massachusetts, with the adjoining eastern border of New York. The *second part* will cover the middle and northern portions of the region. In a *third part*, I propose to discuss the relations to one another of some adjoining rocks that are inferior in position to or older than the limestone.

a. *The map and diagrams.*

The scale of the map is half an inch to the mile; and that of the plottings from which it has been reduced one and a half to two inches to the mile.* The limestone areas are the colored portions. The rocks of the uncolored areas are indicated in many parts by initials, as follows:

M, ordinary mica schist,
cM, chloritic mica schist.
qM, quartzytic mica schist.
stM, staurolitic mica schist.
HM, hydromica schist.
cHM, chloritic hydromica schist.
Q, quartzyte.
mQ, micaceous quartzyte.
Gn, gneiss.

The rocks mQ and qM are intermediate between quartzyte and mica schist.

The strike and dip are indicated on the map by the T-shaped symbols, according to the method explained in volume xx of this Journal (p. 360, 1880); and the values of the angles are stated in annexed figures. (The most of these values consequently are not given in the text, one place of publication being sufficient.). By the method adopted, where the dip is 45° the stem of the T is made half the length of the top; for larger angles, the stem about equals the sine of the dip, half the top being taken as radius; for smaller angles the stem is made longer; and for horizontality, a circle is used. The locality of the observation is indicated by the point of junction of the top and stem of the T.

The positions of the ore-pits and quarries or workings are indicated on the map by a small circle with a letter enclosed to indicate the kind of workings: F signifying iron-ore, which ore in the region is limonite (in miners' language brown hematite); M, manganese-ore; K, kaolin or porcelain clay; Q, quartzyte, the rock quarried in the region for the hearthstones of furnaces.†

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* The completion of unfinished work in the New York part, has led to some changes since the map in the last volume of this Journal (Plate III) was printed.

† The heights stated on the map are in feet; and those along the railroads are heights of the railway at the stations. I am indebted for nearly all of them to the levelings of Mr. W. E. Pettee, Civil Engineer and Surveyor, Lakeville, Connecticut. Mr. F. V. Fyler, of Winsted, gave me (in 1877) for the height of Bald Peak, 1996 feet, as his own determination, and of Bear Mountain by estimate, 2250 feet. The height of Mount Everett, the highest summit of Mt. Washington, is from the Massachusetts survey.

A few localities of glacial markings are recorded by means of a symbol consisting of three parallel lines, with a dot on the middle one marking the locality, and figures at the southern end indicating the angle with the meridian.

The roads are given because they were often used as a base in fixing the limits of rocks and the positions of localities; and also because it was desirable to mark the localities of the stratigraphical sections inserted in the text so plainly that any questioning geologist could go and see for himself and not remain—longer than he wishes—in a fruitless state of doubt.

In the diagrams the symbols for the kinds of rocks are those explained on page 7 of this volume. In the case of the sections, wherever the limestone and schist in superposition were not observed in *actual contact*, a space is left to indicate it, and the length of the interval is usually given in feet; and when these sections were derived from surface outcrops, and not from transverse cuts, this is shown by a vacant space in the lower outer angle of the diagram.

The evidence of conformability between the schist of a ridge and the limestone adjoining it is *perfect* evidence only in case of actual contact between the rocks; it is generally good when there are several outcrops of the two rocks within 50 yards of one another; but beyond this distance, it is uncertain, because the dip in the limestone often becomes reversed within 300 yards and sometimes, a much shorter interval, through an anticlinal. In each diagram ***the east or north end of a section is that to the right hand.***

In the study of Berkshire County I have been much benefited by the geological map of Massachusetts, by Professor Edward Hitchcock, which gives a good general view of the distribution of the limestone and its associated rocks. Percival's map in his Connecticut geological report (1842) has also been of service, and the map of the Vermont geological report (1861) for the Vermont portion. But in all parts of the map herewith published the lines and locations are given from my own personal observations.*

In all geological maps, and especially in one of eastern North America, the lines are in some parts unavoidably conjectural, because the surface is to so large an extent earth-covered, or have the rocks displaced by growing forest trees. Good outcrops of the schist and limestone are numerous; yet they largely fail along the limits between the formations, where of most interest, because these limits are generally near the base of the ridges, and there the limestone has usually been worn away and concealed by the action of descending waters; and not unfrequently has become the bottom of a marsh.

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* A geological map of the Taconic region accompanied my paper printed in the Journal of the Geological Society of London for 1882. In preparing it, the Berkshire and Vermont portions of the map were copied, with very little change, from the maps of the Massachusetts and Vermont geological reports. The map with the limestone area colored, was sent with my paper to the Geological Society, in February, 1882, in order to make the paper intelligible, and not for publication. I soon learned, however, that the Society thought best to publish it. The fact that I was thus to be the author of a geological map which did not contain corrections from my own observations—then too incomplete for satisfactory use—was a strong motive prompting me to a more detailed survey of the Taconic region.

Outcrops along the limits between the quartzyte and limestone are still more rare, because very much of the quartzyte is a fragile crumbling rock and covers its slopes deeply with sandy earth. Some quartzyte ridges present no external evidence of their constitution except a scattering of large quartzyte bowlders over their earthy slopes which have come from the harder portions of the decayed beds. Further, the hard quartzyte has usually joints and uncertain planes of bedding.

The drift, moreover, is a great concealer of rocks, along the valleys of the region, and also very widely over the *western* slopes of the higher north-and-south ridges.

b. *General geological characteristics of the Taconic region.*

By way of introduction, I here briefly state the general geological characteristics of the region as deduced from my present knowledge of the facts.

a. The most striking geological feature is the wide and complicated distribution of the crystalline (or metamorphic) limestone formation in north-and-south lines. The most marked topographical feature is the existence of broad northward trending plains or valleys and narrower parallel valleys separated and bordered by high ridges, which owe their location to the distribution of the limestone, and to the fact that degradation has gone on over this soft, yielding rock to a depth exceeding by 500 to 1,500 feet that over the other rocks.

The rocks of the intervening ridges are various.

b. Along *the Eastern border* of the limestone region there are coarse mica schists, gneisses, and, in many places, quartzyte, mostly older than the limestone, and in part of Potsdam age. Part, at least, of the gneisses are Archæan: as in the higher parts of Cornwall, Kent and Sharon, Conn., where I have found chondroditic limestone and other proofs of Archæan age; at the Hinsdale railroad station in Massachusetts, where I discovered the same evidence of the Archæan; north of and in the cut south of the Washington railroad station, to the south of Hinsdale, where the rock is a zircon-bearing syenyte and syenyte-gneiss; north of central Clarksburg, where occurs a ridge of very coarse zircon-bearing granite (the "Stamford granite" of the Vermont Report); and probably over a central part of the region between the limestone of South Lee and that of Monterey, along the southern side of which I found a loose mass of chondroditic rock like that of Dalton. With regard to the age of the rest of the gneiss of the eastern borders, I have not yet the facts needed for a positive conclusion.

c. Between the Eastern border and the Taconic range the rocks of the ridges include, to the *eastward*, chiefly mica schist and quartzyte; to the *westward*, hydromica schist, changing to the south to mica schist, without quartzyte.

d. The *Taconic range* consists to the north of hydromica schist and to the south of mica schist.

e. West of the Taconic range, the rocks are hydromica schist and argillyte (or phyllyte).

f. All the rocks are metamorphic.

g. In no case is the underlying rock uncrystalline or less metamorphic than the overlying; on the contrary, the two closely correspond in grade of metamorphism.

h. The rocks owe their positions to a system of flexures, and the folds or flexures are to a large extent over-thrust folds. The thrust was westward;—which is proof that the pressure producing the flexures was *from* the eastward. This westward thrust has in no case carried the gneiss of the eastern border over the limestone or over the associated schist ridges, except *perhaps* in two cases, one in the far east Tyringham valley, Mass., and the region of Monterey just west, and the other in South Canaan. I have not observed any gneiss of the kind, or any other true gneiss within the limestone limits north of southern Canaan and Salisbury.

i. The quartzyte of the *Eastern border* is probably of Potsdam age. In 1872 I pointed out that the quartzyte formation of Poughquag, in southeastern Dutchess County, lay between the limestone and adjoining Archæan; and later, that this was true of the same south of Fishkill; east of Dover and Sharon, at the west foot of the Kent-Cornwall Archæan range; south and north of Kent, at the east foot of this range; and I inferred from the position, and apparent conformability in some cases, that its age was Potsdam, or that of the lowest beds of the Lower Silurian of the region. Similar evidence exists farther north, as will be shown in the course of this paper.

j. The quartzyte west of the eastern border, between it and the Taconic range, *overlies* the limestone conformably and is an independent formation, *newer than the* limestone.

On this point I here add a historical note.

In my earliest paper on Berkshire geology, that of 1873, I did not question the direct stratigraphical evidence from the sections, and announced the above as my conclusion. In my paper of 1877, following that on Wing's discoveries, I left the question of age undecided, under the idea, urged by Wing and others, that the stratification might have been reversed by overthrust folds. Again, in my paper of 1879, the doubt is admitted; and in that of February, 1882, presented to the Geological Society, in which the subject is briefly reviewed, I go still further toward the opinion that the quartzyte is "mainly if not wholly, Primordial." In this state of mind, I commenced in the summer of 1882 the new investigations, determined to remove, if possible, the doubt on the question as to reversals by overturn flexures; and the final conclusion is essentially identical with that of 1873.

The conclusions arrived at make the headings of the subdivisions in this and the following part of my paper, and are as follows:

I. The limestone formation is *overlaid* conformably by the schists of the Taconic range and of other ridges of the region east and west of the range.

II. The limestone east of the Taconic range is *overlaid* conformably by strata of quartzyte and quartzytic and ordinary mica schist.

III. The limestone is a single continuous formation; the same is true of the overlying schists and quartzyte.

IV. The limestone is *underlaid*, near or along part of its eastern border, by strata of quartzyte and associated mica schist.

V. Within the Taconic region, crystalline texture and mineral constitution are geographically gradational; that is, vary gradually from north to south and similarly from west to east.

The topics are to a considerable extent the same as in my former papers. But they are illustrated by new facts, with the aid of the new map and many new stratigraphical sections, and lead to some new results.

PART I—THE SOUTHERN PORTION OF THE REGION.

I. *The Limestone formation underlies the Schists of the Taconic Range and of other associated ridges.*

On the map, accompanying this paper, the reader has before him the facts as to the distribution of the limestone (the colored portion); the outlines of the included schist ridges or areas (uncolored); the form or outline of the whole of Mt. Washington, or the Taconic range; and, through the T-shaped symbols, the angles of dip and strike of the rocks along the sides of the broad Mt. Washington synclinal, and in many other parts.

The map exhibits the fact that the ridges of schist which stand isolated within the limestone area,—as isolated as islands in a sea—and which cluster divergently about Mt. Washington, and especially its southern declining portion, are continued from Salisbury, eastward, over Canaan; that eleven of them a fifth of a mile to five miles in length, exist in the town of Salisbury, and eight, of smaller sizes, in the part of Sheffield directly north; that similar ridges occur also to the *west* of Mt. Washington; that one of these western ridges, Winchell's Mountain, is a dividing range between two branches of the limestone formation—one, the branch (see map, plate xiii, in volume xx of this Journal, 1880) that goes to the Hudson south of Poughkeepsie and is in part fossiliferous; the other that which extends by Millerton, and then, after an interruption, bends westward, north of the Putnam County Archæan, to Fishkill on the Hudson.

The elevated region of Mt. Washington has already been shown to be a synclinal of schist with underlying limestone. Beyond I present further details relating to this mountain; and also evidence that the same structure is the common one among the subordinate ridges east and west of the Taconic range. In giving this evidence I commence with the town of Salisbury.

a. Northeast of the railroad station of Limerock, a high bluff, consisting chiefly of limestone, faces the river. This bluff is the southeast front of what is called Gallows Hill, which rises from the limestone plain east and south of it to a height by estimate of about 500 feet.

Gallows Hill, as the map shows, is the common head of two ridges of schist, one of which stretches from it northwestward, the other southwestward.* Each consists, like other Salisbury ridges, and Mt. Washington in part, of a coarse mica schist, much of which is garnetiferous and staurolitic. Being thus alike in rocks, and hence one in origin, we should naturally look for evidences of wrenching and displacements in Gallows Hill, their common head.

Such evidences exist in isolated interior patches and bluffs of limestone, and in other features. Although but a square mile in area, four limestone patches mark the courses of as many faults; one at each 2 and 2′, and two transverse in direction at 3. Besides these, other faults are indicated by bluffs of schist.

The bluff southeast front of Gallows Hill, referred to above,† consists of limestone for about 300 feet, and above this has a cap of the mica schist. The beds dip 8° to 10° southeastward (fig. 1). Great blocks of the schist (and none of limestone) lie at its base, as a result of undermining by the dissolving away of the limestone through descending water. The figure shows *schist over limestone*—the fact in all the sections of the hill in which limestone comes into view.

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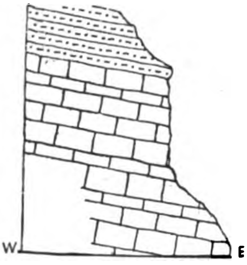
* This *southwestward* direction is probably a consequence of the fact, already stated, that an Archæan area exists to the south and southeast in the hilly region of Sharon, Cornwall and Kent, which was a resisting mass when the uplifts and flexures of the later rocks took place.

† It is near the house of Mr. L. D. Goodwin.

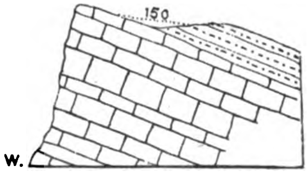
1.



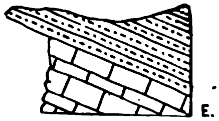
This high bluff, within a hundred yards of its south end, changes abruptly to schist from top to bottom. A fault intervenes, which is covered on the front by a great triangular mass of schist-topped limestone, which has slid down from above. The direction of the fault is from east to west, or about west southwestward; it appears to be the same that gives an abrupt southern limit to the limestone area No. 2′ (see map).

At 2, the summit of Gallows Hill, there is another limestone bluff, rising out of a small limestone area. It faces westward, trends N. 40° W., and has its beds dipping 15° in the direction N. 10°-20° E. The bluff is limestone to the top, but it has a cap of schist just east of its highest point as represented in fig. 2. Another section, from a low ledge a hundred yards farther south, is shown in fig. 3, the schist and limestone in contact.

2.



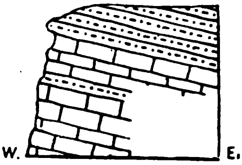
3.



In another ridge on this same area to the southeastward of the first, the upper half is schist and the rest limestone, and the dip is westward (N. 29° W.). The outcrops indicate irregular fracturings and faultings along the region in a northwestward direction.

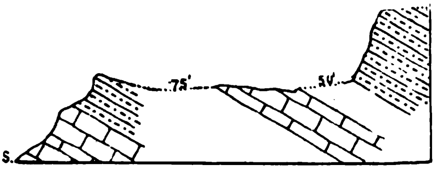
A third prominent line of fault occurs at 2′ where there is another nearly parallel limestone bluff facing west. A cap of mica schist covers the top and in some parts makes a projecting brow, as shown in fig. 4. The limestone at all the localities is impure, though coarsely crystalline, and here there is a layer of mica schist 25 feet thick, besides thinner intercalations.

4.

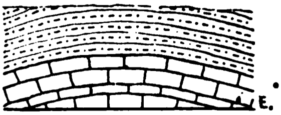


At 3, just north of the last locality, are two narrow parallel bands of limestone, nearly east-and-west in direction, indicating two lines of faulting, transverse to the preceding. Fig. 5 represents a section across the beds from south to north, through the two belts. The southern belt has the overlying schist and limestone in direct contact, with the dip 25°–30° to the northward; and in a front view the beds at the place are arched as in fig. 6. The dip in the northern line is about 35°. These small belts of limestone also have interruptions which indicate irregularities from wrenching in the fracturing.

5.



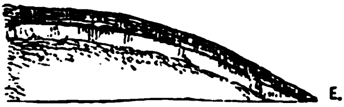
6.



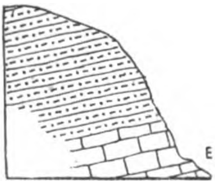
In all the sections in this region the evidence as to order of superposition is of the *perfect* kind. No overturn or westward overthrust is at all probable. For staurolitic mica schist does not exist to the eastward, while it is the rock of ridges to the westward. At the north end of the ridge, five miles to the northwestward, the limestone dips under the schist at the eastern angle, giving further evidence as to its underlying position and the synclinal character of the ridge.

b. Three miles north of Gallows Hill, at 4, there is the south end of another schist ridge. In the view from the southward a thin stratum of schist having the eastward pitch of the surface, overlies, like a blanket, a bed of white limestone, as represented in fig. 7. The limestone directly below the schist has a vertical front with some schist-capped recesses; but south of this bluff portion it spreads widely as the rock beneath the sloping fields, showing itself in occasional outcrops. The dip of the beds is oblique to the section, being 35° to the N. 71° E., the strike being N. 19° W. The section does not show whether the ridge is synclinal, anticlinal, or monoclinal (though a fault).

7.



8.



c. To the northwest of the last locality at 5, is a small ridge of schist, named Turnip Rock. It is about a fourth of a mile long. The schist overlies the limestone in a shallow synclinal, and comes nearer to being a *horizontal* remnant than any I have elsewhere seen. Limestone makes the base of the hill as represented in fig. 8; which figure answers equally well for sections up the hill from the southward, southeastward and eastward.

d. In northeastern Salisbury stands one of the larger ridges of mica schist named Toms Mountain. At its very narrow south end, where it crosses the road (see map), the limestone and schist, in outcrops about a dozen yards apart, may be seen dipping alike, 25°, in the direction S. 81° E.—the strike being N. 9° E. Nothing at the place indicates whether the schist is an intercalated stratum, or the south end of a flexure; for eastward dips exist on both sides of it; and this continues northward to and beyond the railroad. But abreast of the north end of the lake, the limestone extends high up the steep *west* slope of the mountain and passes beneath the schist with a pitch of but 10°. Further, on the *east* slope, nearly half a mile from the Massachusetts line, where the mountain is recessed, it comes out from beneath the schist 50 feet or so above the base of the mountain with a similar small dip. The synclinal is a westwardly careened trough to the south, but a very shallow and broad trough to the north. Nearer the Massachusetts boundary, the schist extends across the road eastward with a small dip.

e. In the part of Sheffield, that lies north of Salisbury and west of the Housatonic, the smallest of the areas of schist is only 200 yards long. A group of these areas in the southern part of the town looks as if consisting of remnants of the west side of Toms Mountain synclinal. The limestone in which they lie, dips beneath the schist conformably on the west side and over it on the east, giving no evidence as to whether they are isolated intercalated layers, or the thin summits of folds, excepting the fact of the relation in position to Toms Mountain just mentioned, and the resemblance of the rock to that of this mountain and of Mt. Washington. The northern of the areas northwest of Sheffield village (where a recess in the rocks is called Bear's Den) is the most northern locality of *staurolitic* mica schist I have met with.*

f. Winchell's Mountain, in New York, west of Mt. Washington, is a ridge of hydromica schist, becoming finer-grained and argillyte-like on the west. To the northward the dip of the schist is eastward, and mostly 35° to 60°. West of Millerton the ridge sends off an eastern spur, southeast in trend; and in the open area between the mountain and the spur, where a limestone plain begins, the limestone comes out from beneath the slates of the mountain almost horizontally (see T-symbols on the map), and disappears in a similar manner beneath the slates of the spur with a dip slightly eastward. The inferior position of the limestone is plain. On the east side of the spur, along the Harlem railroad, where the spur joins a schist ridge of northeast trend, the limestone *overlies* the schist with a dip of 30° (the direction of dip N. 18° E.); the proof of the underlying position of the limestone being accepted, this overlying limestone indicates only a westward careening of the synclinal—the usual fact.

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* The occurrence of staurolite crystals in the mica schist of the small area near the village of Sheffield was first announced by Dr. Chester Dewey, in 1824; and the same in the Salisbury mica schist, by Prof. C. A. Lee, in 1822. (See this Journal, viii, 7, and v, 36.)

g. The evidence that Mt. Washington is a synclinal in structure (or rather a compound synclinal), as already explained in the last volume of this Journal, is well shown on the map; and as the roads are given, it exhibits the facts more intelligibly to the reader than the map of the former paper. Along the west side, eastward dips are universal in both the limestone and schist, and the angle is mostly between 40° and 60°. Along the eastern foot the angle of dip in the schist and the nearest limestone is small in Massachusetts, being 10° to 15° westward at the north extremity in Egremont; 10° to 25° W. along by Spurr's (see map), and about the same in the bluffs near Roys's. In this Massachusetts part, in which the synclinal has a broad tray-like form, the limestone makes a high base to the mountain, it being the rock of the lower 150 to 250 feet. Nearing Connecticut, and within that State, the dip of the schist and limestone at the base of the mountain increases, being 50° to 55° W. half a mile north of the Connecticut line, and mostly 60° to 65° at Sage's Ravine just south of the line. Farther south, west of ore-pit *i* (Camp's) the dip is about vertical, and west of the ore-pit *h* (Scoville's), it has 10° of easting. The synclinal of Mt. Washington is hence shallowest to the north; and, like all the rest, is not a symmetrical trough.

9.

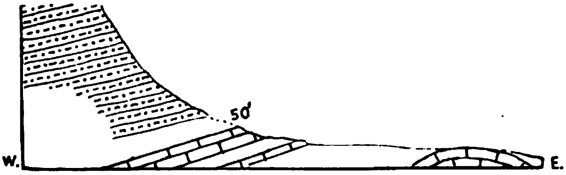
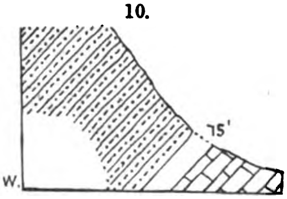


Figure 2 in the Mt. Washington paper (page 271) represents the position of the rocks at 17 on the map, near L. Roys's; and fig. 1, that on the west side of the mountain at 18, east of Weed's ore-pit. The above figure 9, represents a section at

16, near the north end of the mountain, and about 500 yards (by pacing) from the road; and fig. 10, the same at 15.

10.



The small limestone areas in the Mt. Washington region west of Lakeville, and which are probably, as observed in the Mt. Washington paper, decapitated anticlinals, are situated near, and north of, the upper road to Millerton. The quarry of limestone with overlying schist represented in figure 3 of that paper, occurs in area 1; the locality of fig. 4 is along the road at 2; and that of 5 in the field at 3, where a narrow strip of schist separates this area from No. 4. The areas 4 and 6 are probably parts of a single anticlinal flexure, the schist of which still remains over a middle portion. Area 9 is in the bed of a brook near a fence which follows the New York boundary, a short distance north of a bridge over the brook, and about 1,000 yards (by my pacing) north of the carriage road. Area 8 is a doubtful one, since the only outcrop of limestone found was small, and it may be that of a loose mass; yet the ore-bed* and the flat valley south of it are pretty good additional evidence as to the existence of limestone beneath.

Southward dips alternating with eastward occur in the southern extremity of the mountain at outcrops along the road east and west of Lakeville and also to the north.

The western lobe of limestone in southern Egremont extending south into the Mt. Washington area may continue southward to the first road-junction, since a well near there, at Mr. O. C. Whitebeck's (as I am informed by Mr. H. F. Keith, of Great Barrington), has *hard* water. From Mr. Keith, I also have learned that four miles to the south in the same north-and-south line, near the eastern foot of Elk Mountain, there may yet be found a limestone ledge, as an old deed of property reserves the limestone.

II. *The limestone underlies conformably strata of Quartzyte, and of quartzytic or arenaceous Mica schist.*

The limestone of Salisbury and Sheffield spreads eastward across the Housatonic River into Canaan and New Marlborough and covers a large part of these towns. Mica schist is the rock of many ridges within the limestone limits, as it is west of the Housatonic; but it is in most cases a much more arenaceous variety, and it is not staurolitic. Quartzyte is the chief rock of many of the ridges; and it occurs both massive and of the well-bedded fragile kind. The latter is most common; it is often micaceous and graduates into arenaceous mica schist, and thence into ordinary mica schist. These rocks, like the schists of the west side of the Housatonic River, overlie conformably the limestone formation. Farther north in Berkshire county, they occur also to some extent on the *west* side of the river; and one such area extends over the northern border of Sheffield (see map). The following sections exhibit the order of superposition.

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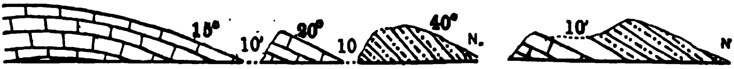
* D. Cook's, and bearing N. 50° W. from Mr. Cook's house.

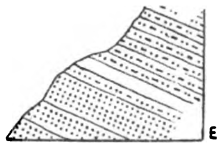
a. West of South Canaan near the house of Mr. T. H. Palmer, and in the fields north and south of it there is the very narrow top of an anticlinal outcrop. Its direction is N. 20°–31° W. By the north side of the house, at a small quarry, the arching limestone has the schist *in place* on the northern side of the arch, as represented in fig. 11. The dips are greater to the right, as shown in the figure, and correspond to the distance from the axis. In the field northwestward the schist continues with the limestone underlying it. The dips are less regular on the south side of the anticlinal, south and west of Mr. Palmer's house, owing to the overthrust character of part of the arch.

11.



b. In South Canaan, near 7 (see map), on the south side of the west end of Cobble Hill, on and near the road, quartzyte of the hard massive kind, micaceous in its upper part, is overlaid by mica schist, the lower beds very arenaceous (fig. 12); the strike is N. to N. 30° E., and the dip 20°–25° eastward. No outcrop of limestone occurs near by to show whether the quartzyte is overlying or underlying.

12.

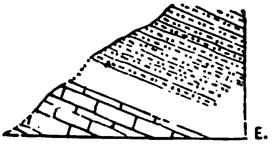


Above the mica schist there is a whitish granitoid gneiss, and this is the rock of the hill to the eastward. It is a remarkably brittle and quartzose gneiss, and apparently comformable to the schist. But a good junction is not exposed and the position is still in doubt. It is one of the two cases of possible overthrust referred to on page 193, and will have fuller description at another time.

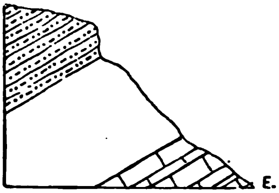
c. Canaan Mountain rises 800 to 1,000 feet above the Canaan plains. It has, on its southwest, west and north sides, a basement of limestone varying in its height above the plain from about 150 to 400 feet. This limestone basement reaches eastward, on the north side to the eastern boundary of Canaan, and, on the opposite to the road up the mountain; and beyond these points rapidly declines.

The dip of this limestone, as the T's on the map indicate, is toward the mountain on the three sides; and the same is true of the overlying schist. Fig. 13 shows the position of the rocks in a section at 8, on the southwestern side, and fig. 14 the same at 9, on the north side near the western end. Fig. 15 represents the section on the north side at 10, toward its eastern end.

13.

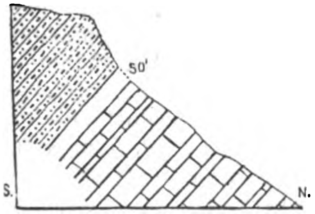


14.

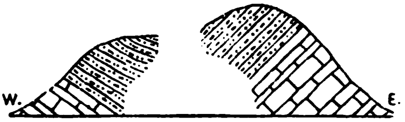


The limestone in its upper portion is often impure with "canaanite" or massive white pyroxene. The beds of schist overlying it are arenaceous, and an interval of bedded or micaceous quartzyte intervenes in places. The thickness of the quartzytic layer I could not determine because sandy soil usually conceals it. In the third section (fig. 15), large masses of hard quartzyte lay over the surface, as evidence of a quartzyte stratum below; the limestone at this point extends 400 feet above the stream at its base. To the eastward the mica schist of the top loses its arenaceous character.

15.



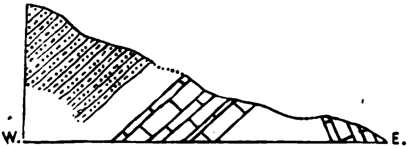
16.



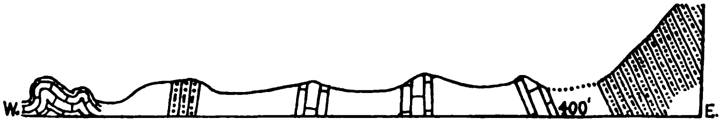
d. Church Hill is a lower elevation, close by the west end of Canaan Mountain (at 11). It is an example of a shallow synclinal. The limestone basement extends high up the hill—farthest on the north side—as illustrated in fig. 16, which is a section from northeast to southwest. A marshy area covers part of the summit, and hence the break in the diagram. The schist of the top is quartzytic mica schist.

e. Rattlesnake Mountain, northeast of the village of Canaan, consists of arenaceous or quartzytic mica schist, micaceous quartzyte and ordinary, but mostly bedded, quartzyte. These rocks rest on limestone in a region of limestone. As the T's on the map point out, the dip in the adjoining limestone on the east side is westward, on the south northward, and on the west eastward, proving its synclinal character; and, as the angles of dip show, the synclinal has its steepest margin on the west and northwest sides. Figure 17 represents a section on the east side at 12, where, in a number of outcrops *close to the foot* of the *mountain*, the dip is westward. East of these outcrops about 150 yards other opposite or eastward dips occur owing to an anticlinal *outside of the synclinal.* Fig. 18 gives the position of the rocks on the west side at 13 (E.N.E. of the house of M. T. Granger), showing conformability to the schist in the limestone at the nearest outcrops, but various flexures outside of the mountain synclinal in the next 400 yards, and very bold flexures in the limestone at the western end of the section. The little limestone ridge of bold flexures is only 40 to 50 yards wide; two partial sections of it, taken at points 50 yards apart, each about 30 feet in actual length, are represented in figures 19 and 20. The facts illustrate the irregularity and variety of the dips in the limestone remote from the base of the ridge.

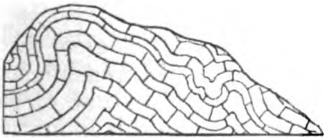
17.



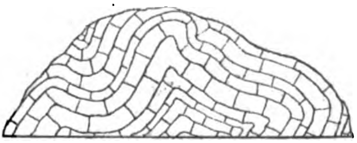
18.



19.



20.



f. Southeast of Rattlesnake Mountain and just west of East Canaan, there are six small areas of hard massive quartzyte insulated in the limestone, the largest 1,400 feet long and the smallest 180 feet. The two larger have their positions given on the map. These areas are described by the writer in a paper in this Journal for March, 1872 (p. 185), and a large map of the region is there given from a manuscript map by Mr. Joseph S. Adams. No good sections showing positively the relations of the quartzyte to the limestone exist about the areas.*

g. The ridge in eastern Canaan, Q Q Q, consists of quartzyte, part of it of the hard massive kind, and part thin-bedded and more or less micaceous. "Hard-heads," or bowlders of quartzyte, are common over it, but little of the rock is in place owing to the depth of disintegration of the porous rock. At the locality in East Canaan, where the Connecticut Western R. R. crosses Whiting River and the carriage road, a deep section exposes to view the quartzyte—a very thinly laminated fragile rock, easily crushed by the hand to sand; its dip at the west end of the exposure is 25° E., but to the eastward it becomes horizontal and westward in dip. No outcrops of limestone occur in the vicinity.

h. The part of Sheffield and of the town of New Marlborough, lying to the north of Canaan, have several north and south ridges of quartzytic mica schist (as is indicated on the map), which are part of the system that extends from Canaan northward through Berkshire. I have not found, in the region, examples of limestone and overlying quartzyte in close or near contact and hence give no sections. Owing to the easy decay of most of the bedded quartzyte, a broad earth-covered surface commonly separates their outcrops; and sometimes such a surface with scattered "hard-heads" is all that is to be seen over their slopes. Good sections occur in the towns next north, and will be described in part II of this paper.

III. *The stratigraphical continuity of the limestone, and also of the beds overlying it.*

The facts which have been presented show that the limestone of the town of Salisbury, is plainly a single stratum or formation, normally underlying, and therefore older than, the schist of the region.

Again: topographical, stratigraphical and lithological facts lead to the similar inference that the schist of Mt. Washington —or the Taconic schist—is one in stratum with that of the various ridges over Salisbury that diverge from this mountain mass and in other cases lie parallel to it.

This limestone continues into Canaan and the towns north;

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* In my article of 1872, referred to above, I make the quartzyte older than the limestone and unconformable to it. The evidence adduced is not conclusive, as it did not depend on a section showing superposition. The argument from the jointed structure and non-bedded character of the quartzyte, and the absence of any corresponding features in the limestone, is set aside by many facts I have since observed.

and no observed facts suggest any doubt as to the unity of the whole. The eastern portion may differ from the western in chronological limits, but all is evidently of one and the same formation.

In Canaan, as in Salisbury, the schists and the associated quartzyte overlie together the limestone and thus present the same stratigraphical proof of identity in formation and age. Further, the schists of Winchell's Ridge overlie the same limestone and have the same claim to be considered a part of the Mt. Washington or Taconic stratum as the ridges to the eastward.

The facts thus sustain the conclusion that the formations outcropping within the region considered are two: one consisting of limestone; and one, overlying this, consisting of mica schist and some associated rocks. Other facts bearing on the question from the rest of Berkshire have yet to be presented.

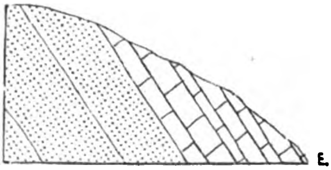
IV. *The limestone overlies conformably strata of quartzyte and associated mica schist, proving the existence of an inferior quartzyte formation.*

Several cases have been mentioned in this paper (p. 209) of the occurrence of quartzyte and schist between the limestone and a neighboring Archæan area. I have also referred above to the fact that the hill region of Sharon, Cornwall and Kent, northeast in trend (and called by me elsewhere the Kent-Cornwall range) has a broad axis of Archæan rock, and a belt around it of the Canaan-Salisbury limestone, as mapped by Percival; and that between the limestone belt and the Archæan on the east side near Kent, and on the west side near Sharon and Dover, exist some of the localities of quartzyte so situated.

The same Archæan area has quartzyte, with the associated mica schist, on its northwestern side or that fronting Salisbury, as indicated by the Q's on the map; and another area on its north side near the boundary of South Canaan and Cornwall. From the position of the quartzyte between the limestone and the Archæan it is probable, as has been stated, that this quartzyte is older than the limestone and of the age of the Potsdam sandstone. No outcrops of limestone occur close against the quartzyte, and we are unable therefore to decide the question as to conformability. We have only the fact of conformity in dip at distant outcrops, both near the village of Kent and near Sharon. Mica schist accompanies the quartzyte on the borders of Salisbury and South Canaan both as ordinary mica schist and the quartzytic variety, *overlying and underlying it conformably;* and the schist does not differ essentially from that over the limestone in Canaan. These quartzyte areas have a hard, gray, well banded gneiss in close proximity, the age of which,—whether of the Quartzyte formation, or of the Archæan, I leave for later discussion.

One well-displayed example of the overlying of limestone by quartzyte conformably occurs in New Marlboro, north of Canaan Valley (at 14 on the map). Fig. 21 represents the section. But it is possible that the overlying is a consequence of an overturn fold. The quartzyte is of the hard massive kind. It is on the east margin of the area which has a bed of kaolin on its west margin.

21.



There is one feature of several of the quartzyte beds that appear to be underlying, which, on further study, may become good lithological evidence of age. This is the occurrence in some of them of a large amount of the coarsely-feldspathic variety of quartzyte, and as a consequence of this, the existence in or near them of large beds of kaolin. Such a conjunction occurs in the quartzytic region of northeastern Sharon and in others to the north in Berkshire. The case of New Marlboro is probably one of these, although the feldspathic variety of the quartzyte has not yet been found there in place.

I omit further remarks on this lower quartzyte and its relations to the associated schists, including the adjoining gneiss, until I have given the subject another season of field study.

The lithological facts from the region considered illustrate an important principle in regional metamorphism; the results as to degree of change, and kinds of minerals produced, are geographically gradational, they varying regularly from north to south and from west to east. A review of the facts on this point will close this part of my paper.

[To be continued.]

ART. XXVIII.—*Variations of Latitude;* by ASAPH HALL.

THE International Geodetic Conference held at Rome in October, 1883, presented to the notice of astronomers the question of the variability of latitudes. A plan of observation was proposed to the Conference by Mr. Fergola, an Italian astronomer, who has made the matter a special study, and this plan was referred to a committee composed of Messrs. Villarceau, Bakhuyzen, Cutts and Schiaparelli. This committee reported favorably, and in due time the proposed plan has come to the Superintendent of the Naval Observatory through the veteran leader of geodesy, General Bäyer, the head of the Prussian Geodetic Survey.

According to the plan of Mr. Fergola the variations of latitude are to be investigated by special series of observations, made with the best prime vertical transit instruments on selected lists of stars. An important feature of the plan is that the work is to be chiefly differential. Two observatories are to coöperate; for example, one in Europe and one in America, and these stations are chosen so that the difference of latitude is small. It being thought best to confine the observations to established observatories, in order that similar series may be more certainly made in the future, Mr. Fergola has selected the following stations:

Stations selected.	Diff. Lat.	Diff. Long.
Cape of Good Hope—Sydney	4′ 22″	8h 51m
Santiago—Windsor (Aust.)	9 47	9 14
Rome—Chicago	3 53	6 40
Naples—New York (Columbia Coll.)	6 22	5 53
Lisbon—Washington	11 7	4 31

At such stations as these the stars that pass near the zenith, and which are best suited for determinations of latitude, can be observed at both stations at nearly the same zenith distance. The conditions would be such that the variations of refraction would be small; and if the observations are made with care and skill, and with the best appliances of modern astronomy, the difference of latitude of the two stations must be determined with the utmost accuracy. If the observations should be repeated after an interval of fifty years or more, the question of the variability of latitudes would be subjected to a severe test.

The Conference has raised an old question which was once much discussed among astronomers. Two centuries ago the notion that latitudes vary during the year was a common one, but the progress of astronomy, and the complete reduction of observations with better tables of refraction, have caused the disappearance of nearly all the anomalies that formerly appeared, and the general opinion has tended toward the idea that latitudes have no sensible variations. Still, this is a result that *à priori* would not perhaps seem probable. Thus we might have geological changes that would alter the position of the vertical line at a station; or again, such as would cause a gradual or secular change in the position of the earth's axis of rotation, by shifting large masses of matter on the earth's surface or in its interior, and these changes might produce variations of latitude. In fact it is for the purpose of testing local changes that Mr. Fergola has chosen stations which have a large difference of longitude. The table of latitudes published some years ago by this astronomer does seem to show a secular change in the latitudes of northern observatories. This table is as follows:

Place.	Date.	Latitude.
Washington	1845	+ 38° 53′ 39″·25
Washington	1863	38 ·78
Paris	1825	48° 50′ 13″·0
Paris	1853	11 ·2
Milan	1811	45° 27′ 60″·7
Milan	1871	59 ·19
Rome	1810	41° 53′ 54″·26
Rome	1866	54 ·09
Naples	1820	40° 51′ 46″·63
Naples	1871	45 ·41
Königsberg	1820	54° 42′ 50″·71
Königsberg	1843	50 ·56
Greenwich	1838	+ 51° 28′ 38″·43
Greenwich	1845	38 ·17
Greenwich	1856	37 ·92

It will be seen here that without a single exception the latitudes given in the table have diminished during the present century. But these variations are small, and during these intervals of time so many changes have occurred in the instruments and among the astronomers that the diminution of latitude may be only apparent. The most complete investigation of this question is that by Mr. Nyrèn of the Pulkowa Observatory. In this case the observations have all been made with the same instrument, and the observations are of remarkable accuracy. The probable error of a single determination of latitude is only ± 0″·2. The results for the latitude of Pulkowa are:

Observer.	Date.	Latitude.
Peters	1843	+ 59° 46′ 18″·73 ± 0″·013
Gylden	1866	18 ·65 ± 0 ·014
Nyrèn	1872	18 ·50 ± 0 ·014

Here again we notice a small diminution of latitude. In each determination also the observations are so numerous that probably the accidental errors of the observer have been almost completely eliminated. Thus the number of Peters's determinations is 371, Gylden's 236, and Nyrèn's 155; all from observations of the pole star. It may seem hypercritical to doubt results that have been deduced with so much care and skill, both in observing and reducing; but still we must remember that these are absolute determinations of latitude, that three different observers took part in the work, and that the variation from Peters to Nyrèn is only 0″·23. An astronomer of experience would be cautious, I think, in ascribing this difference to an actual change of latitude. But the evidence in this case supports that drawn from Mr. Fergola's table. It is well, therefore, to examine how far more recent determinations confirm the results of this table. A recent and very complete discussion of the latitude of the Greenwich Observatory by Mr. Christie, the present Astronomer Royal of England, gives from the observations of the years 1836 to 1879 the following values of the latitude:

1836—1849 Latitude = 51° 28′ 38″·15
1851—1865 Latitude 38 ·13
1866—1879 Latitude 38 ·17

These results give no evidence of a secular change of latitude. Again, a determination of the latitude of Washington, in 1883, gives

Latitude = 38° 53′ 38″·94,

and this result also furnishes no proof of a change of latitude. These negative results show that in the case of the latitude of Pulkowa we must wait for further proof before assuming a real secular change in the latitude of that Observatory.

So far as periodical changes of latitude are concerned, there is a theoretical reason why such changes might occur. If our earth at the origin of things received its motion around the sun and its motion of rotation on an axis from a single impulse, the direction of the impulse would pass about twenty miles from the earth's center, and it would seem to be but little probable that the earth would begin to rotate around one of its principal axes. But the observed constancy of latitudes shows that such was very nearly the case, or that some cause has acted to bring the instantaneous axis of rotation practically into coincidence with the principal axis. These periodical changes depend on the structure of the earth, and the distribution of its matter. They are, therefore, quite different from precession and nutation, which are produced by exterior disturbing forces, chiefly by the action of the sun and moon. The theory of these periodic motions was given by Euler in 1765. The period of the change of latitude depends on the moments of inertia of the earth, and the values of these moments are given approximately from the observed values of the precession and nutation. An expression of the periodical change of latitude is found easily from Euler's equations for the motion of a rigid body. This results from the first step in the approximate solution of these equations, but it is sufficient for all the purposes of observations. If A, B, C, are the moments of inertia about the principal axes, and φ denotes the latitude, the general expression for the latitude is

$$\varphi=\varphi_0+\rho\,.\cos\left\{\sqrt{\frac{(C-A)\,(C-B)}{A\,B}}\,n\,.\,t+\xi\right\},$$

in which $\varphi_0+\rho\cos\xi$ is the latitude at the epoch of t, n is the velocity of rotation of the earth on its axis, and ρ and ξ are constants to be found from observations. The expression under the radical sign must be positive, since otherwise the motion of rotation of the earth would not be stable. If we substitute the values of the moments of inertia, the expression takes the following form in which the unit of time is a year:

$$\varphi=\varphi_0+\rho\,.\cos\,(431^\circ{\cdot}0\,.\,t+\xi).$$

Hence the instantaneous axis of rotation makes a revolution around the principal axis in 305 days.

We have now to see what the observations have shown in regard to this periodical variation of latitude. The first careful investigation of this question was made by C. A. F. Peters, of Pulkowa, from his excellent series of observations with the Ertel vertical circle. These observations extend over thirteen months, and from their discussion Peters found for 1842,

$$\rho=0''{\cdot}079\pm0''{\cdot}017.$$

A similar discussion was made by Nyrèn of the three series of observations made by Peters, Gylden and himself with the same instrument, and the results are,

$\rho=0''{\cdot}101\pm0''{\cdot}014$, Peters, 1842.
$\rho=0\ {\cdot}125\pm0\ {\cdot}020$, Gylden, 1866.
$\rho=0\ {\cdot}058\pm0\ {\cdot}015$, Nyrèn, 1872.

This is a very good agreement of the results, and it is worth while to notice that the parallax of the pole star comes out positive from each series, and that the resulting value of the constant of aberration agrees well with the best determinations. An investigation made by Mr. A. M. W. Downing of the latitude of Greenwich from the observations for the ten years 1868–1877 gives

$$\rho = 0''\cdot075 \pm 0''\cdot015.$$

The first thing we notice about these results is the smallness of ρ, which is the maximum variation of the latitude, and also the fact that in every case it is from four to eight times as great as its probable error. From this relation of the probable error one might infer the reality of ρ, but we ought to consider the form of the equation of condition. This will contain the two unknown quantities, $x = \rho \cos \xi$, and $y = \rho \sin \xi$. The solution will give us

$$\rho \cos \xi = \pm m$$
$$\rho \sin \xi = \pm n,$$

and from the nature of the case ρ will always be a real, positive quantity. The small values of ρ show that the variations of latitude are also small, and it is from the values of ξ that we must judge whether the results are harmonious and really probable. Reducing the values of ξ to a common epoch, the agreement is not good. We infer, therefore, that these investigations do not indicate with any certainty a variation of latitude having the period of 305 days.

From what precedes it appears that observations do not prove that latitudes are variable, and the evidence points rather to other sources of small changes that may depend on the seasons. Perhaps some of these may arise from the tables of refraction which are in common use, and which are assumed to fit the whole earth. It is possible that for the best absolute determinations of zenith distances the question of refraction will need to be investigated for each Observatory.* The method of observation proposed by Mr. Fergola seems to have a great advantage over those that have been followed heretofore from the fact that it is differential. But it is evident that even in this method the observations must be made with the utmost care, and with due consideration of all the surroundings, in order to detect the variations of latitude which we know must be very small.

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*It is not uncommon to exaggerate the accuracy with which latitudes are known. We have only to refer to our ephemerides to find much larger differences than the probable errors will warrant. Thus the latitudes of Greenwich given in the Berliner Jahrbuch and the American Ephemeris differ by 0"·3.

Naval Observatory, 1885, January 21.

Art. XXIX.—*Notes on the Jurassic Strata of North America*; by Charles A. White.

At various places in Colorado, Wyoming, Dakota, Utah, Montana and other western Territories, there are frequent and large exposures of a formation which geologists and paleontologists have agreed in referring to the Jurassic period. It has received recognition as of that age in all the official reports which have noticed it; and from all members of the U. S. Geological survey who have written upon the subject. Professors Marcou, Newberry and Hayden and other early explorers recognized the formation as Jurassic, but it is to the late Mr. F. B. Meek that is due the credit of giving the first exposition of its claims to that recognition, based upon a publication of its invertebrate fauna. It is true that this fauna, even as it is at present known, is a meager one, but its character, together with the position of the formation in relation to those which underlie and overlie it, has been deemed sufficient warrant for the opinion referred to.

The formation in question is usually spoken of simply as Jurassic, but it has received local names by some authors, and some of its divisions have also received subordinate names. Some geologists have also grouped the whole formation together with a large series of underlying beds which have been generally considered as of Triassic age, under the compound name of Jura-Trias. Major Powell called the Jurassic portion, the Flaming Gorge Group: and Professor Marsh, dividing the Jurassic beds into two parts, has given the upper part the name of Atlantosaurus beds, and the lower part the name of Sauranodon, or Baptanodon beds.

It is in the lower division only, so far as I am aware, that any invertebrate fossils have been found: and it is upon these that was based the earliest published opinion as to the Jurassic age of the formation. But from both divisions there has been obtained an exceedingly rich and remarkable vertebrate fauna. This fauna has been brought out mainly by Professor Marsh, who has published the results of his investigations in this Journal from time to time during the past eight years. It is mainly reptilian, but it also embraces many mammalian forms. Professor Marsh refers all this remarkable fauna unhesitatingly to the Jurassic period, and all paleontologists agree with him in this respect. Let it be remembered that a part of this vertebrate fauna is associated in the same layers with the invertebrate fauna which has been referred to, and a part of it comes from layers which overlie them.

The discovery of this great vertebrate fauna seemed to settle the question of the Jurassic age of the formation in the minds of paleontologists generally; but Mr. J. F. Whiteaves, Paleontologist to the Canadian Geological Survey, has lately published in one of the volumes of that survey, views which are entirely adverse to those hitherto held by all others.* In that work he describes and figures some fossils which were collected by Mr. James Richardson and Dr. G. M. Dawson at Queen Charlotte Islands, on the west coast of British Columbia. The fossils are reported to have come from a series of strata some 13,000 feet in thickness, all of which are referred to the Cretaceous period. The principal fossiliferous horizon of this series is about its middle, and it bears an abundant and characteristic Cretaceous molluscan fauna, which is regarded by Mr. Whiteaves as equivalent with that of the Gault or Middle Cretaceous.

Among this Middle Cretaceous fauna Mr. Whiteaves announces his identification of eight or nine molluscan species with forms that are common in our Jurassic rocks, to which reference has already been made. He therefore regards our Jurassic formation not only as of Cretaceous age, but he places it in the middle of that series. With sincere regard for the paleontological ability of Mr. Whiteaves, I quite fail to agree with him either as to the Cretaceous age of those strata, or with his identification of any of its species in the British Columbian rocks. He has stated his case plainly in the publication referred to; and upon the occasion of a late visit to the museum of the Canadian Survey at Ottawa he kindly permitted me to examine the British Columbian collections, including the specimens which he regards as identical with species found in our Jurassic rocks. The following is a list of the species to which he refers them; following which are my remarks, based upon an examination of his specimens and a considerable familiarity with the type specimens of those species.

1. *Belemnites densus* Meek & Hayden.
2. *Lyosoma Powelli* White.
3. *Myacites* (*Pleuromya*) *subcompressa* Meek.
4. *Astarte Packardi* White.
5. *Arca* (*Cucullæa*) *inornata* M. & H.
6. *Modiola* (*Volsella*) *subimbricata* M. & H.
7. *Pteria* (*Oxytoma*) *mucronata* M. & H.
8. *Camptonectes extenuatus* M. & H.
9. *Gryphæa Nebrascensis* M. & H.

(1.) *Belemnites densus.* Mr. Whiteaves's collection contains only one specimen which he refers to this species, and that is too imperfect to be satisfactorily identified as belonging to any particular species out of many that might be mentioned. See his figure of it (loc. cit.)

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* See Volume i, Part III, Mesozoic Fossils. Dawson Brothers: Montreal, April, 1884.

(2.) *Lyosoma Powelli.* Mr. Whiteaves was in doubt as to the true identity of this form with his *Vanikoro pulchella.* I am confident that the two shells are not only specifically different, but that they belong to separate families; the *Vanikoro* to the Neritopsidæ, and the *Lyosoma* to the Velutinidæ.

(3.) *Myacites* (*Pleuromya*) *subcompressa.* The British Columbian collection contains many specimens of the form which Mr. Whiteaves refers to this species, showing a wide range of variation; but they are all in such a state of preservation as to show only the external form and surface characters of the shell. They also belong to a type of shells which, so far as can be determined from the fossils as they are usually found, ranges from the Carboniferous to the Cretaceous inclusive. Indeed this type is so constant in general character that its variation in any part of its great chronological range is scarcely greater than is the interspecific variation which Mr. Whiteaves has shown to exist among his British Columbian specimens. Therefore I regard the identification of a species belonging to this type as unreliable if opposed by contrary evidence.

(4.) *Astarte Packardi.* The British Columbian specimens which Mr. Whiteaves refers to this species are certainly very closely like the type specimens of *A. Packardi*, so far as external form and surface characters are concerned. It is also in these respects much like an unpublished form which I have seen among a collection of Cretaceous fossils from New Mexico. The hinge and interior markings of this form, as well as that of *A. Packardi*, are unknown; and they cannot therefore be compared in these important respects with the British Columbian specimens.

(5.) *Arca* (*Cucullæa*) *inornata.* Mr. Whiteaves's specimens are not in a condition to show the hinge, nor are their external characters well preserved. He refers his shell to the genus *Grammatodon*, but I could discover none of the characters by which its exact generic relations may be known among the numerous divisions of the Arcidæ.

(6.) *Modiola* (*Volsella*) *subimbricata.* Only three specimens were obtained at Queen Charlotte Islands, and these are distorted and too imperfect for satisfactory specific identification.

(7.) *Pteria* (*Oxytoma*) *mucronata.* Mr. Whiteaves had only one imperfect specimen of one valve. The most that can be said of it is that it apparently indicates a form which is much like the *P.* (*O.*) *mucronata* of Meek & Hayden.

(8.) *Camptonectes extenuatus.* Mr. Whiteaves refers his specimen, a single valve, with doubt to this species. In view of the imperfection of his material and the slight range of specific variation in this genus I think his doubt is well founded.

(9.) *Gryphæa Nebrascensis.* Every paleontologist knows how unsatisfactory is specific identification among the Ostreidæ. Even if the resemblance between the British Columbian and Dakota specimens is really as great as Mr. Whiteaves thinks it is, there would still be room for doubt as to specific identity, especially in view of conflicting evidence. In fact, however, they differ from each other quite as much as many recognized species do; and the British Columbian form is more nearly like *Gryphæa navia* of the Cretaceous of Texas, than the *G. Nebrascensis* of Meek & Hayden.

A glance at the foregoing list will show that nearly all the genera there represented are noted for the small range of variation which is observable among the species of each. In fact they are just such forms as those upon the specific identification of which one ought least to rely; especially in case the specimens are not numerous and perfect, and the incidental evidence is conflicting.

There is another important fact which deserves great consideration in this connection. The British Columbian specimens are associated with numerous characteristic Cretaceous forms, the latter constituting the more distinctive feature of that fauna. On the contrary, not one of those, or any other distinctively Cretaceous types has ever been found in our Jurassic strata at any of the many hundreds of localities, extending over many thousands of square miles, at which fossils have been collected from it. And our Jurassic molluscan fauna is also very constant in its character at all the places where it has been found. Furthermore, Mr. Whiteaves does not claim to have discovered any of our Jurassic Ammonitidæ, nor Jurassic vertebrates, in the British Columbian rocks.

Whatever may be the true geological age of the formation which all American geologists have hitherto referred to the Jurassic, its identity with any of the strata from which Mr. Whiteaves' fossils came is, in my opinion, in no measure proved by any of the species he has shown them to contain. Still, such challenges of received opinions as he has made are not only the privilege of every paleontologist, but they serve an excellent purpose in causing men to examine more closely into the ground of their opinions, and call for a public statement of their reasons for holding them.

Although I do not regard the evidence which Mr. Whiteaves has presented as at all supporting his position, there are two circumstances which apparently favor the doubt which the publication of his views may have raised as to the true age of the formation which we have always regarded as Jurassic.

First, the invertebrate fauna of that formation is meager. Second, there is, as I believe, always an *apparent* conformity between the Dakota Group of the Cretaceous series and the Jurassic formation, wherever they have been found in contact. While I do not think that this conformity really proves that there is no hiatus between the two formations, I think the circumstance of its existence more worthy of consideration than the assumed specific identification of the fossils which I have commented on. I regard these circumstances as at most only slightly opposing the evidence in favor of the Jurassic age of the strata in question which is afforded by its fossils, especially its vertebrate fauna.

These Jurassic strata are evidently not homotaxially related to the other North American strata which have by some authors been referred to the Jurassic. I refer to the Aucella-bearing rocks and their equivalents, which have been found in California, Washington Territory, British Columbia, Alaska, and the east coast of Greenland. Mr. Whiteaves follows Eichwald in referring these strata to the Neocomian; and I have suggested that they occupy a position upon the confines of the Neocomian and Jurassic. These west coast and arctic beds appear to have no true equivalents in the United States to the eastward of the Pacific Coast region.

ART. XXX.—*Meteoric Iron from Coahuila, Mexico;* by N. T. LUPTON.

WHILE on a visit to Mexico in July, 1879, I was shown a a mass of iron, said to be a meteorite, near the house of a gentleman who lived in the vicinity of Santa Rosa, a small town in the State of Coahuila about 120 miles south of Eagle Pass, Texas. According to information received at the time, this meteorite was found in the desert between Santa Rosa and the city of Chihuahua, about one hundred miles distant from the former place, and was brought to Santa Rosa by a Mexican named Juan Garca. I was also told that twelve years previous to my visit an expedition was sent out to bring in several similar masses from the same locality, which were secured and sent to the United States by Dr. Butcher, an American who was then living at Candela. The mass from which I succeeded in detaching about half a pound was said to weigh 192 lbs., but I had no means at hand to verify this weight. It was of irregular shape, measuring in three perpendicular directions 13, 11, 8 inches. A small piece had apparently been cut from one end. Owing to its strong resemblance to common malleable iron, and to the fact that nitric acid failed to develop the so-called Widmannstättian figures on a surface carefully polished, I was led to doubt the statement of its origin. Since that time, however, my attention has been called to the article of Dr. Lawrence Smith on "Coahuila Meteorites of 1868" in this Journal, vol. xlvii, page 383, and in his "Scientific Researches," page 346, in which several similar masses are spoken of as having been brought to this country from near Santa Rosa. This induced me to analyze carefully a portion of the piece now in my possession with the following results.

Iron	91·86	Cobalt	·50
Nickel	7·42	Phosphorus	·27

Dr. Smith's analysis of a specimen from one of the masses above mentioned yielded:

Iron	92·95	Cobalt	·48
Nickel	6·62	Phosphorus	·02

Copper, very minute quantity.

The similarity of composition in connection with other circumstances convinces me that these are, in all probability, fragments of the same meteorite. It is proper to state that after careful examination I failed to find the least trace of copper.

According to the account which Dr. Smith received from Dr. Butcher, a brilliant meteor passed over the town of Santa Rosa in the fall of 1837 and was heard to explode with a tremendous report after its disappearance among the mountains toward the northwest. Search was made for it the next day by Dr. Long of Santa Rosa with a party of friends, but without success. Some years later, Dr. Butcher undertook the search, an interesting account of which is given in the article above referred to.

Dr. Smith remarks that while it matters little whether the time specified is that of the fall of these masses, nevertheless, "it forms one of the most interesting groupings of meteoric irons known in any part of the world, especially as the masses are solid and compact, and not fragile and half stony, as the Atacama iron, that may have been broken artificially after its fall, and the fragments scattered by Indians and explorers in search of silver. Each one of these masses merits a separate examination, which I hope to be able to give sooner or later to satisfy my mind on one or two points connected with their common physical and chemical composition."

Dr. Smith's description is applicable to the specimen in my possession.

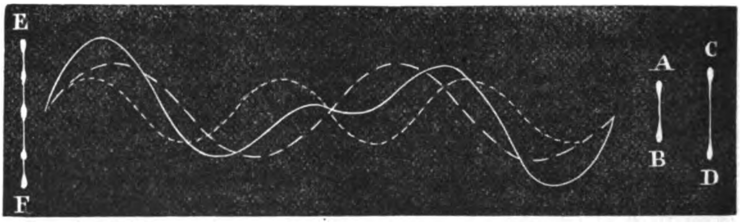
Vanderbilt University, Nashville, Tenn.

ART. XXXI.—*Optical Projection of Acoustic Curves;* by W. LECONTE STEVENS.

THE following application of a well known principle may be of sufficient interest to teachers of Physics to justify its publication; it has not been elsewhere described, so far as is known to the writer.

By appropriate measurements on paper the sinusoids representing the tones composing any group of musical sounds can be compounded, and the resultant curve represents the concord or discord produced. The construction of such curves involves much tedious work. Any of them may be easily produced and optically presented on a screen by a simple modification of the method commonly employed in projecting Lissajous' curves.

1

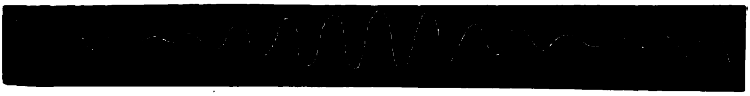


Optical Presentation of a Concord.

Select a pair of tuning forks provided with mirrors and sounding tones whose vibration frequencies bear to each other such a simple ratio as 2:1 or 3:2. Let us suppose the tones selected to be C and G, with sixty-four and ninety-six vibrations per second respectively. Arrange the apparatus as for Lissajous' experiment, except that both forks shall vibrate in vertical planes. At any convenient distance in front of the fork from which the second reflection of light occurs, place a mirror capable of revolution about a vertical axis, such as is used with the manometric flame. From this the spot of light is focussed upon a screen.

Excite the G-fork; the spot is lengthened into a narrow vertical band, faint in the middle and brighter at the ends, as approximately shown in fig. 1, AB. Turn the mirror; the band is broadened out into a series of sinusoids, three of which are represented by the short-dotted curve in fig. 1. Arrest this fork and excite the C-fork; a longer vertical band, CD, is produced; and, on revolving the mirror, this is spread into sinusoids, two of which are represented by the long-dotted curve. Excite both forks while the mirror is at rest; a vertical band is seen, longer than either of the previous ones, with spots of increased brightness not only at the ends but also at intermediate points, the beam of light being momentarily arrested at several intervals in each compound vibration (fig. 1, EF). On revolving the mirror, a series of compound curves appears on the screen, one of which is represented by the continuous curve in fig. 1. In this the two forks are supposed to begin exactly together. If there be any other combination of phases than this, the result is a corresponding modification in the form of the curve. Practically, by loading either fork very slightly, the curve may be changed through all its modifications within a few seconds.

2



Optical Presentation of a Discord.

Select a pair of unisonant forks, and arrange as already described. Load one of them until any desired number of beats per second is produced. Excite both forks while the mirror is at rest. The vertical band of light grows alternately long and short, with the swelling and softening of the sound. Revolve the mirror rather slowly but uniformly; the sinuous curve broadens vertically at every beat and is narrowed at every approximate silence (fig. 2). By using forks of moderately high pitch and obtaining six or eight beats per second, discord may be seen and heard at the same time.

This method of exhibiting the composition of musical sounds is in some respects preferable to the method of manometric flames, being visible at a greater distance, and showing more readily the effect of difference of initial phase in determining the quality of a combination, as emphasized by König.[*]

The optical projection of simple vibratory motion is quite familiar. Tyndall,[†] Blaserna[‡] and others, have described a method of projecting the curves representing beats; but their method is that of giving rapid motion to the tuning fork from which the second reflection of light occurs. With so small a mirror, fixed upon a heavy fork, great skill is needed to ensure success, and at best the exhibition is only momentary; or, if continuous, it is by giving angular motion in successively opposite directions, and hence with variable velocity, around a point on the mirror. Thus no two successive sinusoids can have the same length. By keeping both forks fixed, and utilizing the revolving mirror, which may be regulated by clockwork if necessary, any desired constant rate of horizontal motion on the screen is secured. Either or both forks may be made to vibrate with constant amplitude by means of a well known electro-magnetic attachment.

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[*] König, Acoustique, pp. 222–243, Paris, 1882.

[†] Tyndall, Sound, pp. 366–369, Appleton, 1877.

[‡] Blaserna, Sound and Music, pp. 150–152, Appleton, 1876.

Brooklyn, Jan. 31, 1885.

ART. XXXII.—*Measurement of Strong Electrical Currents;* by JOHN TROWBRIDGE.

IN 1871 I described in this Journal a new form of galvanometer which I called the Cosine galvanometer. Six or seven years after the appearance of my paper, with a large wood cut of my instrument, the same instrument was re-invented in England by Mr. Obach, and the instrument now goes by the name of the Obach galvanometer in England, and is manufactured by the Messrs. Siemens, for the measurement of strong electrical currents.

In the prosecution of an investigation upon dynamo electric machines I abandoned the cosine galvanometer in favor of a dynamometer which I invented, and a full description of which will be found in the proceedings of the American Academy of Arts and Sciences, and also in the London Philosophical Magazine. It seemed to me then, and I have had no reason to change my belief, that a dynamometer is the most suitable instrument for measuring strong currents. I have lately, however, employed the cosine galvanometer for this purpose in the following manner: The galvanometer is mounted so that its compass is at the center of a large circle of wire, the plane of which is vertical and is in the magnetic meridian or in the plane of the needle of the compass, whatever that is. When the current from a dynamo machine is passed through the large vertical coil, which may consist of a single wire, the arrangement answers as a tangent galvanometer. I then connect the movable coil of the cosine galvanometer with a Daniell cell of known electro-motive force, place in the same circuit a resistance so large that the battery resistance can be neglected, and having joined the poles in such a manner that the deflection produced by the coil of the cosine galvanometer shall be opposite to that produced by the current from the dynamo machine in the large outer coil, I incline the coil of the cosine galvanometer until the compass needle is brought again to zero.

We then have, if we represent by F and F′ the force produced at the center of the coils by the current from the dynamo machine and by the Daniell cell, S and S′, the respective currents; r and r', the radii; n and n', the number of coils in the two galvanometers, and H the horizontal force of magnetism:

$$F=\frac{2\pi nSH}{r}=P'=\frac{2\pi n'S'H}{r_{\prime}}\cos\alpha \text{ or } S=\frac{S'n'}{n}\frac{r}{r'}\cos\alpha$$

The strength of the current from the dynamo is thus simply obtained in terms of the current from the standard Daniell cell, and the method is independent of the strength of the earth's magnetism, or of the special field in which the instruments may be placed. The diameter of the outer coil can be diminished by employing Professor Brackett's method of passing the current through one coil in one direction and through an inside coil in another. In an experimental trial I employed simply a scaffolding of wood, upon which a single turn of wire was fixed as a vertical circle.

Jefferson Physical Laboratory.

ART. XXXIII.—*Divisibility of the Archæan in the Northwest*; by R. D. IRVING.

[Extract from Address as retiring President of the Wisconsin Academy of Sciences December 30th, 1884.]

I WILL next ask you to follow me in a rapid description of the occurrences to be met with in the Penokee-Gogebic iron region of Lake Superior.* This is a belt of country some sixty miles in length, stretching from Lake Numakagon in north Wisconsin to Lake Gogebic in north Michigan. The course of the belt is in general north of east. Its position and those of the various rock belts of the region are indicated on the accompanying sketch-map (p. 240).†

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* The facts upon which the arguments and conclusions of this paper are based are in part given in vol. iii of the Geology of Wisconsin, which includes an account of the work done in the Penokee District of Wisconsin by Professor Chamberlin, Mr. C. E. Wright and myself. Since that time further investigations in this region have been begun in connection with the U. S. Geological Survey by my assistant, Professor C. R. Van Hise, who has extended the work of the Wisconsin Survey into Michigan as far as Lake Gogebic. In working over his results we have taken occasion to revise in some measure the Wisconsin Survey work, the collections of that survey being at our command. After having re-examined some of the more important and difficult points in the field during the coming season, it is our hope to prepare together a general account of this very interesting region. By special permission of the Director of the U. S. Geological Survey, I am able to make use of knowledge gained in our work in this region for the present paper.

† The map which was used in connection with the address, and from which this is reduced, was drawn on a scale of two inches to the mile. In reducing so very greatly it is difficult to illustrate all of the points spoken of. The map is designed only to represent the distribution of the formations in a general way.

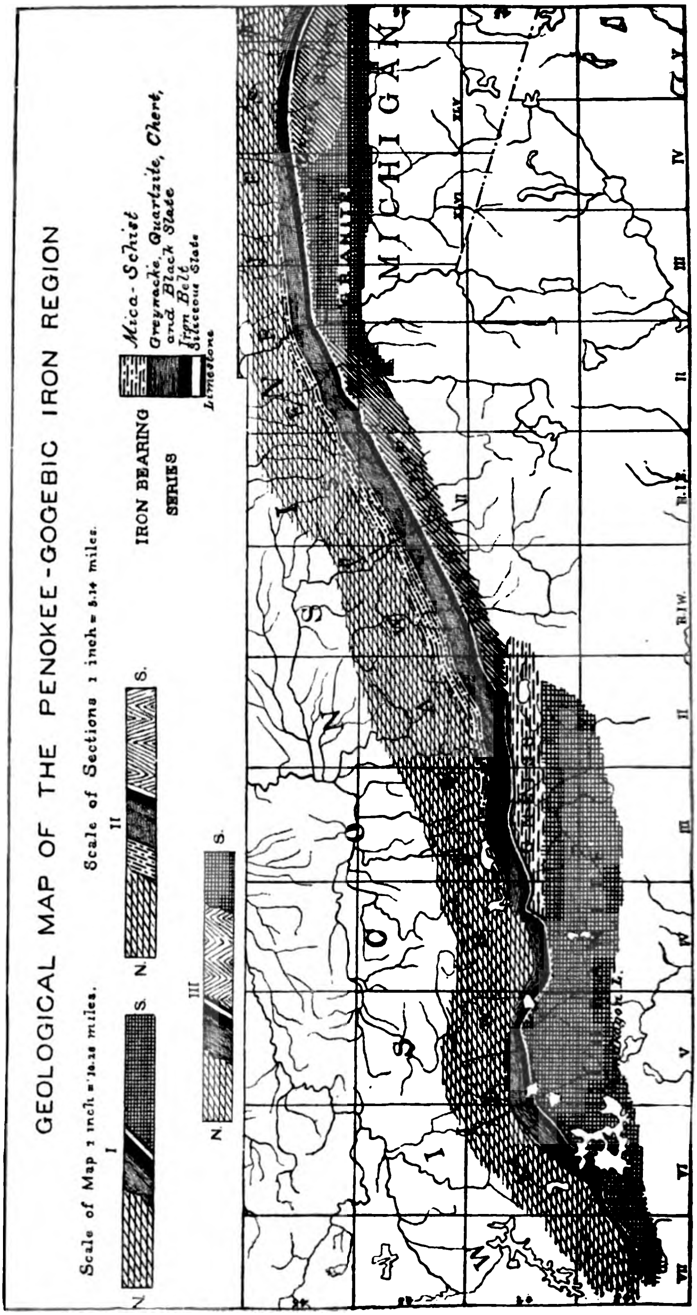
In the southern part of the area mapped, we find ourselves in the northernmost portion of a great area of gneiss and granite, associated with which in large proportion are highly foliated and crystalline hornblendic and chloritic schists, with some mica-schists. In some of these schists distinct evidences are here and there met with of their fragmental origin. These schists and gneisses are arranged more or less distinctly in belt form, but the granite with them occurs in great irregular areas, which at their junction with the more regularly bedded rocks are inextricably interwoven with them. Greenstones of various kinds also occur in intrusive form. The whole series is highly crumpled, and, if the schists and gneiss are in any measure the result of the metamorphism of sediments, as they certainly appear in part to be—witness the occurrence in the schists of unquestionable fragmental material—then the metamorphosing process has been carried very far. The northern edge of this gneissic and schistose formation is not formed of any one of the rocks which go to make it up, but is seen to be made here of granite, there of gneiss, again of schist, and again of some form of basic eruptive, the foliation planes of the gneiss and schists commonly making a greater or less angle with the bounding line.

Passing now beyond this northern limit of the gneiss-granite-schist area—which stretches all the way southward to Central Wisconsin—we find ourselves on a belt of slate which averages some 500 feet in width. This belt may be traced continuously from the vicinity of Lake Gogebic to that of Lake Numakagon in Wisconsin. It includes many varieties, which range from vitreous quartzite to quite fine-grained clay-slate; but all are plainly fragmental, and do not present evidences of any considerable alteration. The quartzites are always merely indurated sandstones, and often the induration is feeble, and the rock little more than a friable sandstone. Except when we reach the immediate vicinity of Lake Gogebic, where a change in structure comes about which we cannot now discuss, the layers of this sandstone belt dip always to the northward, usually at rather high angles. Following this belt on the north, we find a regular succession of belts of quartzite, graywacke, black slate, iron-bearing cherty rocks of various kinds, and mica-schist or mica-bearing quartzite; all of which rocks continue to dip to the north. Certain interbedded and intersecting masses, plainly of eruptive origin, occur, but, with the exception of these, and of certain belts believed to be in part of direct chemical origin, the whole succession is made up of layers which contain but little original crystalline material and to which the term "metamorphic," in the sense of more or less thorough recrystallization from the sedimentary condition, is hardly applicable.

Next north again of this succession of layers, we find, following them, in what appears at first sight to be a conformable manner, the alternating sandstones and eruptives of the Keweenaw series. A closer inspection, however, shows that this apparent conformity is apparent only, consisting merely in an approximate general parallelism of the layers, which does not indicate that the one set of rocks has been succeeded by the other without interval of time; for, as we follow the junction line of the two terranes eastward or westward, we find the overlying formation in contact, now with the highest layers of the under one, again with its middle layers, and again with members near its base. Evidently such a relation can find only one explanation; the lower formation has been raised above the sea and subjected to a long continued erosion before the deposition upon it of the higher one. The accompanying diagram will make this relation and explanation so obvious that further description will be unnecessary.

The same diagram will also certainly suggest at a glance that this upper unconformity is not the only one in the region. The very striking manner in which the southern limit of the regularly arranged succession of belts of the slaty formation is formed, to the southward, now by granite, again by gneiss, and again by some sort of schistose rock, certainly suggests a great break at this horizon. If the gneisses, granites, etc., to the south of this limit, after being smoothed down by atmospheric agencies had then formed the sea-bottom upon which the slaty series was piled up by the ordinary processes of sedimentation, the relations would be precisely such as we have here.

To the argument, which has been and doubtless again will be presented as bearing against this conclusion—that the more southerly rocks are, or may be, of eruptive origin, and therefore are naturally irregular in distribution, so that those to the north necessarily come in contact with different kinds in different places—I would say that, accepting for the moment, and for the sake of the argument, the eruptive origin for them, it is to be observed that these same southerly rocks certainly have not been extravasated subsequently to the deposition of the succession of slaty beds. Had they been so, it is inconceivable that a series of eruptions different as to materials and times of extravasation should all have stopped so nearly on one geological horizon. Some of them would, on the contrary, quite surely have deeply invaded the slates. But of such an invasion no sign whatever is to be seen, either in the general geographical arrangement of the different kinds of rock, or of the structural details observed at the contacts. Moreover—and this argument, it seems to me, there is no evading—the slates contain abundant fragments derived from the more


GEOLOGICAL MAP OF THE PENOKEE-GOGEBIC IRON REGION
Scale of Map 1 inch = 10.18 miles.
Scale of Sections 1 inch = 5.14 miles.
I
II
III
N
S
IRON BEARING SERIES
Mica-Schist
Greywacke, Quartzite, Chert, and Black Slate
Iron Belt
Siliceous Slate
Limestone
GRANITE
MICHIGAN
WISCONSIN
Gogebic L.
R.1 E.
R.1 W.
II
III
IV
V
VI
VII

southerly granites, gneisses and schists, so that, if eruptive, these southern rocks were extravasated prior to the deposition of the oldest members of the slaty series, and thus formed the basement upon which the latter was accumulated. But—the opposing argument would be—granting all this, there is yet no proof advanced of a great break, inasmuch as, even at the present time, eruptives of modern origin are having geologically contemporaneous sediments piled against them. The mere superposition of sediment upon an eruptive is no proof of a geological hiatus between the two. In answer to this argument it is to be said that the case we are considering finds no parallel among such modern occurrences. The gneisses, schists, granites, etc., forming our supposed eruptives, are, if eruptive, manifestly not to be compared with the lavas of modern times. On the contrary, their completely crystalline character and general structure would force us to believe that they solidified far within the depths of the earth, and that, therefore, before they formed the bottom of the sea within which the slaty beds were accumulated, they must have been subjected to an enormous atmospheric erosion; and that, consequently, we *do* have evidence here of the existence of a genuine geological break, even on the view that the more southerly rocks are all eruptives. But an eruptive origin for all of these rocks, thus admitted for the moment, and for the sake of the argument, I can by no means accept. The granites I do consider as of eruptive origin. That they are so is rendered manifest, as it seems to me, by the way in which they intersect the associated schists at their contacts with them. Such intersections, as already noted, are never found at the contacts of the southern granite with the overlying slates. It remains to be proved, however, that any of the gneisses and schists we are here dealing with are of eruptive origin. Some of the schists most manifestly are not so; for, while mainly made up of original crystalline material, they yet contain at times matter quite evidently of fragmental origin, as may be seen both microscopically and on the larger scale. Now, if these gneisses and schists *are* of sedimentary origin, then they certainly passed through processes of dislocation, alteration and erosion before the deposition upon them of the earliest member of the overlying series.

So far, however, I have considered only the general relations of the two sets of rocks. Other arguments, in favor of the existence here of a great unconformity, can be drawn from certain minor, yet very important phenomena to be observed at the contacts of the two formations. In the first place, at several of the points where actual contacts, or close approximations of exposures of the two formations are to be observed, there is a marked discordance in strike and dip between the lamination directions of the older schists and newer slates, while at others of these points these directions are more nearly in parallelism. In the newer or slaty series, the lamination, being manifestly the result of sedimentary deposition, conforms always to the general courses of the slaty belts, and, since these courses vary considerably, as indicated on the accompanying chart, the lamination directions vary also. Such a relation of lamination planes as this—discordance at some points, accordance at others—is precisely what should be expected along an unconformable contact line, and could occur under no other circumstances; the underlying rocks being, in part at least, certainly of sedimentary origin. It is no argument against this view, to maintain that the lamination of the older set of rocks is in this case what is known to geologists as foliation, and not the result of sedimentation. I have little doubt that it is often foliation, i. e. a structure in some way due to the intense squeezing which these older schists have undergone, and one which very possibly often occupies a position quite oblique to the original bedding directions. Manifestly, however, this foliation must have been produced before the deposition of the first of the overlying slaty rocks, for otherwise the latter must have been affected also by a foliation similar in character and direction. But there is no true foliation about them, and what there is occasionally approaching it is always manifestly parallel to the bedding planes, and thus commonly discordant with that of the schists below. The occurrence of foliation on one side of a contact line, and its absence on the other, where this contact is one between two great and dissimilar sets of rocks, is in itself strongly suggestive of the existence here of a great unconformity. Moreover, two points, at least, have been observed on this contact line, where this discordance in the directions of the lamination of the older and newer rocks is to be made out, not merely from closely approximated exposures of the two formations but from actual visible contacts. Descriptions of both of these localities have already been published.* The contacts are certainly not those of eruptives with previously formed sediments; on the contrary, they are exactly what they should be, had the lower schists formed an irregular bottom upon which the newer slates were deposited.

Still another thing going to show the complete distinctness between the two sets of rocks we are considering is the plentiful occurrence, in certain layers of the higher series, of fragments derived from the lower one. These fragments occur at times a third of the way up in the newer series. They are also to be seen, however, at its base, on the contact line. There are places, as has recently been ascertained by Professor C. R. Van Hise, of the U. S. Geological Survey, where one may pass within a few steps from ledges of gneiss of the older formation to others of the lowest member of the newer, the slate being crowded with fragments derived from the gneiss. Even the matrix portion of the rock is composed of gneissic detritus, while a few paces farther away from the gneiss it has graded into an ordinary quartzite, i. e. is merely an indurated sandstone. As is, of course, well known to every geologist, the mere occurrence of fragments of a lower rock within the mass of a higher one does not always prove a great time gap between the two rocks, but merely the relative ages of the two; for any rock which reaches the solidified state rapidly may yield of its material to overlying sediments as soon as beaten upon by the waves of the sea. Thus lavas, and certain forms of chemical deposits, have furnished fragments often to geologically contemporaneous beds. The present case, however, finds no parallel in such occurrences, for here, even if admitted for the sake of argument to be eruptive, the rock which has furnished the fragments has quite certainly never solidified at the surface, but has had removed from it before it could be broken by the waves of the sea an immense thickness of rock material. Moreover, it is not only the gneisses that have furnished fragments to the overlying series. Fragments of the schists accompanying them are also frequently met with in the slates of the upper series.

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* Geol. of Wis., vol. iii, pp. 98, 116, 117. Also Annual Report of Geol. Survey of Wisconsin for 1877, p. 26.

It may be said, in passing, that these "recomposed" rocks, which occur in these slates, close to the sources of the detrital material of which they are made, have quite striking parallels among the Triassic sandstones of the Connecticut Valley. These sandstones lie in a trough of granite, gneiss, mica schist, etc. They are described as nearly always highly feldspathic, and little sorted. At certain points the sorting process has been so entirely omitted that the indurated detritus is, macroscopically, difficult to distinguish from the parent rock. Professor J. D. Dana, to whom I am indebted for first calling my attention to these recomposed Triassic rocks, has kindly furnished me with specimens of the sandstones and of the crystalline rocks from which they are derived. We have made and studied thin sections of these sandstones and have compared them with a number of the recomposed rocks from various points in the Lake Superior Archæan region, and have found them to be of precisely the same nature and origin.

Attention should next be invited to certain occurrences indicated on the accompanying diagram,* which have been appealed to as indicating the formation by eruptive agencies of the more southerly rocks subsequently to the formation of the entire series of higher ones. We have already seen that these southern rocks, if eruptive, must quite certainly have been formed prior to the more northerly series, the occurrence of detritus from them in the latter alone being sufficient to render this certain. But even were this not manifestly so, the occurrences of which I am about to speak, as I think, furnish no arguments to the contrary. The accompanying outline map shows that while the base of the slate series is usually made up of the slate member to which reference has repeatedly been made, there yet, at times, comes between it and the lower rocks a thin layer of limestone. Upon this occurrence the argument has been based that, since the lower rocks come into contact with different members of the higher series, they are of necessity subsequent eruptives. Now in the first place, there is good reason to believe that the limestone here concerned is a mere local phase of the slate member itself; and, in the second, even if it be a distinct member of the series, then its occurrence at some points and absence at others is precisely what should be expected, if we are here dealing with an unconformable contact; for the surface of the lower rocks would of course have some corrugation, in the depressions of which the lower layers of the slate series would accumulate, while the elevations would remain uncovered. Indeed, as any one glancing at the accompanying map must admit, the line of contact here is singularly free from such irregularities as might on this view reasonably be expected to occur.

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* Difficult to show on the small scale of the reduced figure printed herewith.

Summarizing, then, I find proof of the existence of a great unconformity between the two formations we have been following:—

1. In the manner in which the regularly succeeding belts of the higher series traverse the courses of those of the lower.
2. In the strong contrast between the two series as to rock kinds, the bedded members of the lower series having arrived at a nearly complete recrystallization, while those of the higher are but little altered.
3. In the highly folded and contorted condition of the lower series, as contrasted with the unfolded condition and simple stratigraphy of the higher.
4. In the striking contrast between the contacts of the granite with the lower schists and with the higher slates, the former being invaded by it in an intricate manner, the latter never, when the two come together;*

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* Granite in veins and intersecting masses occurs among the upper mica schists of the Penokee series (see map) but this always of a different character from the granite at the southern contact which has, as yet, never been found to intersect the slates.

5. In the discordant laminations of the two sets of rocks when seen in contact or close proximity.

6. In the occurrence in the upper series, not only at horizons above the base, but also at points on the contact line, of abundant detrital material derived from the lower series.

The succession of formations in this region is, then, as I see the matter, as follows, beginning with the southernmost or oldest: (1) *gneiss-granite-green-schist formation;* great unconformity; (2) *iron-bearing slate formation;* unconformity; *Keweenaw series.*

Turning next our attention to the Marquette Region of Michigan, we note at once, that, while the slaty iron-bearing formation here displayed is manifestly and by common consent the same as that of the Penokee-Gogebic region just described, in one point it presents with the latter a marked contrast. I refer to its highly folded condition. In a general way, it may be said that the rocks of this region lie in a trough or troughs whose sides are formed of granitic and gneissic material. Within the troughs the slaty rocks are strongly crumpled. With regard to their stratigraphical arrangement somewhat discordant views have been held, the crumpling having made correct determination in this respect often difficult. There can, however, as it seems to me, be no question that Dr. C. Rominger, whose personal acquaintance with the Marquette region is more extensive than that of any other geologist, is correct in regarding certain greenish schists, which frequently intervene between the iron-bearing slates and the granite and gneiss, as the basement upon which the rest of the slaty series was spread. These greenish, generally hornblendic schists, are Rominger's "Dioritic Group," and, if of sedimentary origin, as they seem in some measure undoubtedly to be, they are now in a highly metamorphosed condition, being in the main made up of original crystalline material. Where these greenish schists come into contact with the bounding granite, the latter penetrates them in the most intricate manner, so that one cannot resist the conclusion that it is the more recently formed rock. From this unmistakable relation, regarding his Dioritic Group as the lowest member of the slaty or iron-bearing series, Dr. Rominger naturally passes to the conclusion that the granites are, in large measure, subsequent to this entire series, whose present crumpled and trough-like arrangement he connects with the subsequent protrusion of the granite masses on either side. To me, however, it seems plain that, in the greenish schists at the base of the Marquette iron-bearing series we have the equivalents of those just described as occurring south of the Penokee-Gogebic iron-bearing series, like which they form, as I conceive, part, not of the higher, but of the lower formation. On this view, the structure of the Marquette region becomes plain. The slate series above the greenish schists, in the main composed of relatively little altered rocks, was originally built up upon a basement composed of granite, gneiss, *and* these greenish schists themselves, and subsequently was pushed into trough-like forms by lateral pressure. Denudation then brought matters to their present condition.

To support this view we have many of the same arguments as advanced in the case of the Penokee region. Discordance of lamination, on account of the highly crumpled condition of the whole succession, and of the common lateral pressure to which both basement rocks and overlying slates have been subjected, is here naturally not to be readily made out. But the other arguments, viz: the penetration of the greenish schists by the granites where the two come into contact, as contrasted with the entire absence of any such relation, where the bounding granite forms contacts, as it does at a number of places, with the slates and quartzites above the greenish schist group; the occurrence in the lower series of only highly altered sediments, gneiss and granite, while the higher rocks are relatively little altered; the occurrence in the higher series of fragments from the lower, "re-composed" rocks, occurring at points where the quartzites of the upper series come into contact with the gneisses of the lower—all of these arguments hold here as well as in the Penokee region. Here then again it seems to me plain that we have to deal with a *lower* or *greenish-schist, gneiss-granite member*, and a higher, unconformably overlying, *slaty, iron-bearing member*.

Thus it appears that in two portions of the Lake Superior Region we have a distinct separation of the Archæan into two members. Were the time at our disposal, and could it be done without wearying you, I could, I think, present similar arguments in favor of the existence of two similar divisions at various other points in the Lake Superior Archæan Region.

There is, indeed, one way in which we can avoid the conclusion which, as it seems to me, has thus been forced upon us, viz: that the Archæan of this region is divisible into at least two wholly separate members. This is by throwing the newer of the two divisions into the Cambrian and calling only the lower one of the two Archæan.* By so doing, however, we should extend the term Cambrian from the fossiliferous Potsdam downward over two great unconformities and two enormously thick and entirely unfossiliferous sets of rocks. If any good reason can be advanced for so greatly extending the term Cambrian—or for using any other term or terms of equal taxonomic value with Cambrian, to cover the space between the Potsdam sandstone and the base of the iron-bearing slates—then, with my present knowledge of these formations, I am as strong an advocate as any of the indivisibility of the Archæan. Not that I would maintain the certain absence of unconformities among the rocks to which the term Archæan would thus be restricted. I would merely hold that we have as yet no evidence upon which to base any separation. However this may be, it is to be noted that the upper one of the two members into which I have maintained that the Archæan of this region can be divided has always played the part of typical Archæan in the writings of the various geologists who have described the region, and this not only with those who have maintained the divisibility of the Archæan but also, and very prominently, with those who have maintained its indivisibility. To me it seems very improbable that this generally accepted reference of the iron-bearing series to the Archæan can ever be proved erroneous in any other save one way, viz: by the discovery in them of fossils. This is, of course, a discovery that may be made at any time. The rocks are, in the main, less altered than many of later date carrying fossil remains. Until this discovery is made, however, we must, I think, continue to call them Archæan.

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* This is essentially what N. H. Winchell would do in referring all of the western Huronian rocks to the Taconic of Emmons (Amer. Naturalist, October, 1884, pp. 984–1000). With the Taconic system, and, indeed, with the whole "Taconic question" I have little acquaintance, but I cannot feel any great confidence in the parallelization of formations so distant from one another as the western Huronian and the "Taconic," on exclusively lithological evidence. However this may be, there is, in Professor Winchell's general arrangement of the crystalline rocks of the northwest, much with which I can cordially agree.

The question next arises as to the names we shall use for these two divisions of the Lake Superior Archæan.

It is now many years since Sir William Logan, after an ex-

Still, there are certain points in it with regard to which I feel confident that he is mistaken. The most important of these points, in the present connection, is the reference of the original Huronian of Canada to the quartzite and marble series which forms so prominent a feature at the base of the iron-bearing rocks of the Marquette, Menomonee and Penokee districts. In doing this we parallelize a series of enormous thickness (15,000 to 18,000 feet), with one only a few hundred feet in thickness, there being, at the same time, every reason to believe that the two formations are actually continuous. Moreover, although Logan's generalized descriptions do not necessarily convey the idea, a study of the ground shows that the black slates and cherty ferruginous rocks, characteristic of Winchell's Groups III and IV, occur in the original Huronian; while there is on the north shore of Lake Huron a mica schist or micaceous quartzyte which has always been mapped by the Canadians as Huronian and which *may* represent the mica-schist of Winchell's Group II. But I have never designed, in parallelizing the original Huronian with that of the Marquette and Penokee regions, to indicate my belief that it covers exactly the same range as they. If it is equivalent to any part of, or to more than all of, the Marquette and Penokee iron-bearing series, inasmuch as in these series there is no evidence whatever of any discordances or separations, we are justified in speaking of the two latter series as Huronian.

perience in these regions which has yet been equalled by no living geologist, separated the Archæan or Azoic formations of Western Canada into a lower gneissic member and a higher quartzitic slate member, which he called respectively by the now well known names of *Laurentian* and *Huronian.* For the latter formation he took as his type the series of rocks which is displayed along the north shore of Lake Huron, between the St. Mary's and Thessalon rivers. Having examined this formation somewhat thoroughly, I have no hesitation in saying that in it we find the equivalent of the iron-bearing slates of the Marquette and Penokee regions, in which opinion I merely follow a succession of geologists. Like the latter formations it is in the main composed of quartzite and slate, with various cherty and limestone beds, and with many included eruptives, and like them also it is distinctly a feebly altered series. Where its basal quartzite member comes into contact with the underlying gneiss, which forms the north shore of Lake Huron for a number of miles east from Thessalon River, and which has been mapped by Logan as Laurentian, a most beautiful basal conglomerate is to be seen. The quartzite, here little more than a feebly indurated sandstone, becomes thickly crowded with masses of granite, gneiss and schist, the quartz sand of which the rock is usually composed giving place, also, in large measure, to an unassorted detritus plainly derived from the adjacent gneiss.

Sir William Logan's able successor in charge of the Geological Survey of Canada, Dr. A. R. C. Selwyn, has recently said that Logan nowhere asserts an unconformity between his Laurentian and Huronian, and, indeed, that he could not have believed in such an unconformity. To me, however, it seems plain that Dr. Selwyn must be mistaken as to this. That Logan believed in such an unconformity seems evident to me from his sections of the region north of Lake Huron in the atlas (Geological Sections, Plate I) to the Geology of Canada (1863), and in his descriptions given in that volume, although he does not make the statement in so many words. In speaking, for instance, of the contact of the Huronian with the gneiss on Lake Temiscamang, he describes it as filled with fragments from the gneiss. Now, manifestly, such an occurrence, on Logan's plainly expressed view as to the sedimentary origin of gneiss, can only be explained by a great time-gap between the two formations.

It is, of course, well enough known to any geologist, who has worked with these older formations to any extent, that the terms Laurentian and Huronian have been greatly abused, having been applied often on the very feeblest of lithological evidence. It is also manifest to any one with such experience that where the two series are infolded, as in the Marquette region, and again on the north side of Lake Superior, there must often arise great difficulty in separating the newer slates from the older schists. Such considerations do not, however, seem to me to take away anything from the arguments I have advanced in favor of the existence of a separation, for the region from Lake Huron to southeastern Dakota, of the Archæan formations into two distinct members.

As I now see the matter, then, all arguments recently presented to the contrary notwithstanding, I certainly believe in a division of the Archæan, for the region in question, into two discordant members, to which for the present at least we should continue to give the classical names of *Huronian* and *Laurentian*.

Art. XXXIV.—*Mineralogical Notes*; by W. E. Hidden.

Phenacite, a new locality.—To Mr. J. G. Hiestand of Manitou Springs, Colorado, I am indebted for a few specimens of quartz, topaz and amazonstone (microcline), on which I have found implanted, colorless crystals of phenacite in considerable numbers. These specimens were discovered last summer at Florissant, El Paso County, Colorado, about thirty miles (by the road) from the locality previously announced by Messrs. Cross and Hillebrand in this Journal. The phenacites are well polished and transparent, and are commonly highly modified. They vary in size from one to five mm., are invariably lenticular in shape, with little or no prismatic development and are implanted usually edgewise. A determination of the specific gravity yielded 2·954, which is rather low considering the perfection of the crystals. Three different rhombohedrons, two scalenohedrons and three prisms were observed but their angles could not be determined with exactness with the means at hand. Later I shall endeavor to figure them and describe them more accurately.

They had been considered minute topazes up to the time they were brought to my notice; their rhombohedral aspect decided me, however, to make the determination above given. With these phenacites were found several hundred crystals of topazes, many of them, large and small, still attached to the matrix and perfect in form.

Xenotime, a new locality.—From the same source as the phenacite and topaz above noted I have received, along with some bastnæsite, a single tetragonal crystal of 5·1 grams weight. I am informed that it was found with bastnæsite and at the same locality where the tysonite and bastnæsite were originally found, near Pike's Peak, Colorado. A fragment tested qualitatively showed the presence of phosphoric acid, iron, lime and one of the rare earths, probably yttria. Its sp. grav. was 4·48, but after soaking two days in water increased to 4·92. It was porous (through decomposition?). The planes 1, *I*, *O* were largely developed, *O* having been unknown heretofore. Angles=$1 \wedge I = 129°$, $1 \wedge O = 140° - 141°$, $1 \wedge 1$ ov. $O = 102°$, $1 \wedge 1$ ov. $I = 78° - 80°$.

The crystal was over one centimeter square, of a chocolate brown color and like wiluite in type of form. Implanted upon it were small crystals of similar character. There can be no doubt of its identity with xenotime. The prismatic (*I*) cleavage was not observed for the reason of superficial alteration.

Fayalite (?), *from Colorado.*—Also from the same source and same region as the phenacite, I have received large masses, uncrystallized, of a mineral which may prove to be fayalite. The sp. grav. is 4·35, the color dark brownish-black. Slight evidence of cleavage in two directions. It contains silica and iron and traces of manganese and lime. It is fusible and gelatinizes with acids.

These characters agree pretty closely with fayalite, though the density is somewhat high. It was found in quartz and granite in "vugs," on Cheyenne Mountain, Colorado; masses of many pounds weight occur at one of the localities.

Zircon, a new plane.—I have lately observed on a crystal of zircon from Burgess, Canada, a very low pyramid which after measuring gave the following results with hand goniometer:

on $I = 106°$ to $107°$, over $O = 146°$, over $I = 34°$,

all of which angles closely correspond with the required angles for the plane $\frac{1}{3}$. The plane $\frac{1}{3}$ has not before been observed to my best knowledge. In addition to the above obtuse pyramid, which was largely developed and smoothly polished, the planes 3, 1, *O*, *I*, 3-3 and two other zirconoids, were observed, the last two, however, were too rounded for exact determination. This particular crystal was an unusually fine one and weighed nearly 4 grams.

Rutile.—The old locality in Alexander County, N. C., at Johnson's Mill (now Crouch's) was lately re-opened by Mr. W. H. Lackey and yielded some very fine prisms of rutile of remarkable brilliancy and polish. Some of the crystals were 1 cm. thick, and 8 cm. long and perfectly terminated with many bright planes. Held up to the light the crystals had the color of pyrargyrite. The fracture was bright conchoidal. The planes 1, 1-*i*, 1-3, 3-$\frac{3}{2}$, *I*, *i*-3 and *i*-*i* were observed and measured with hand goniometer.

Emeralds and Hiddenite, a new occurrence.—In October last Mr. W. H. Lackey of Stony Point, N. C., discovered a new pocket of emeralds, hiddenite, quartz, etc., on the Osborn Lackey land in Alexander County, N. C. This new discovery is distant about one-fifth of a mile northwest from the mine of the Emerald and Hiddenite Mining Company, and joins the land formerly known as the Lyon's property. About fifty crystals of emerald, 2 cm. to 7 cm. long and from 2 mm. to 8 mm. in diameter, were found. They were all transparent but of pale color and but one of the crystals was large and pure enough to be cut into gems. The Hiddenites found were very inferior and of very pale color. The curious rough edges and pseudo-horizontal striations were noticed on nearly all of the crystals of emerald, these markings being peculiar to the beryls of the region. Only the planes *I*, *i*-2 and *O* were found. The particular interest attached to this occurrence is the fact of the locality being somewhat distant from the old one and for this reason it is encouragement for future work.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the influence of Temperature on Spectrum measurements.*—The connection between refractive power and density has been known from the time of Newton, who gave a formula expressing the relation. Gladstone and Dale, Jamin, Schrauf, Landolt and others have shown that in liquids the refractive power increases with density and therefore with diminution of temperature. Rudberg examined solids and found aragonite and quartz to follow the same law; but he showed that the refractive power of glass increases with rise of temperature; a fact also observed by Arago and Neuman previously. Krüss has now measured three prisms at various temperatures in order to ascertain the amount of this change and to determine its importance in ordinary spectrum measurements. The measurements were made by means of a micrometer which moved the observing telescope, in connection with an eye piece micrometer contained in the latter. The apparatus was placed in a room in which constant temperature could be maintained. About one and a half hours were requisite to bring the apparatus to any required temperature, but two hours were always allowed before making any measurements. Indeed it was easy to see by the lines whether the instrument was undergoing change of temperature, since they in that case would shift position. The results are given in the following tables, in which the readings of several Fraunhofer lines are given in divisions of the micrometer:

1. GLASS PRISM OF 60°.

Temp.	*C.*	*D.*	*E.*	*b.*	*F.*
15° C.	2561·3	2723·2	2942·6	2979·4	3140·7
30° C.	2565·8	2727·8	2948·5	2983·9	3146·3

2. QUARTZ PRISM OF 60°.

18° C.	-----	313·5	397·5	414·3	470·0
29° C.	-----	311·7	396·5	411·5	468·1

3. TRIPLE RUTHERFURD PRISM.

14° C.	1172·4	1436.2	1804·9	1866·4	-----
16° C.	1173·1	1437·2	1806·5	1867·7	2150·9
20° C.	1174·4	1438·4	1807·3	1868·5	2152·8
30° C.	1177·7	1442·0	1811·0	1872·2	2158·6

From this it appears that this shifting of the spectrum lines by change of temperature is considerable enough to be important, a rise of 25° changing the position of the lines as follows:

	C.	*D.*	*E.*	*b.*	*F.*
Glass prism of 60°,	+7·50	+7·67	+9·83	+7·50	+9·33
Quartz prism of 60°,	----	−4·10	−2·27	−6·36	−4·32
Rutherfurd prism,	+8·28	+9·06	+9·53	+9·06	+13·75

All spectrum lines, then, shift by rise of temperature; in glass prisms toward the violet; in quartz prisms toward the red. Moreover this shifting increases with the refrangibility of the region examined. The importance of this change appears more distinctly by a comparison of the micrometer readings with the wave-lengths in millionths of a millimeter, given at two temperatures the Rutherfurd prism being used.

	C.	*D.*	*E.*	*b.*	*F.*
Micrometer readings,	1169·4	1432·9	1801·5	1863·1	2144·8
Wave-length at 5°,	656·8	589·7	527·4	517·7	486·5
Wave-length at 30°,	658·9	592·0	529·0	519·2	488·0

A change of temperature of about 5° suffices therefore to alter the measurement of wave-length by an amount equal to the distance between the D lines.—*Ber. Berl. Chem. Ges.*, xvii, 2732, Dec. 1884. G. F. B.

2. *On a New Method of determining Vapor-pressures.*—RAMSAY and YOUNG have devised a new form of apparatus for determining vapor-pressures both of liquids and solids. The substance is placed in a test-tube having a lateral opening, the top being closed by a rubber stopper through which pass (1) a thermometer having its bulb covered with cotton, and (2) a glass tube connected with a bulb above and drawn out below to a point which is bent so as to touch the stem of the thermometer. By means of the lateral opening the tube may be put in communication with a reservoir connected with a Sprengel pump. A suitable jacket enables the tube to be heated to any required temperature. The reservoir is immersed in a cooling mixture. To make an experiment, the

apparatus is thoroughly exhausted, and by means of a spring clip, the liquid to be examined, which is contained in the bulb, is allowed to trickle down the thermometer and thoroughly moisten the cotton wool. The spring clip is then closed and the tube heated, the temperature and pressure being noted so soon as they become constant. A little air is then admitted and a second reading of pressure and temperature taken, care being observed to keep the cotton constantly moistened. The process is continued until a sufficient number of observations have been taken. When a solid is to be submitted to experiments, the bulb of the thermometer is previously covered with it by dipping it repeatedly in the melted substance. The results of a determination of vapor-pressure are given in the case of acetic acid, the curve yielded by them when plotted being absolutely coincident with that obtained by the usual process when air and moisture are rigorously excluded, the substance being perfectly pure.—*J. Chem. Soc.*, xlvii, 42, January, 1885. G. F. B.

3. *On the Non-formation of Periodic oxide* (*Iodine pentoxide*) *by direct synthesis.*—Since the heat of formation of periodic oxide is positive, and is equal to 44,860 calories, according to Thomsen, we should expect that iodine and oxygen would unite directly to form this substance. Wehsarg has made a series of experiments to test this question experimentally. In the first, oxygen charged with iodine vapor was passed through a glass tube containing a plug of platinized asbestus 7 or 8 cm. long, and heated to a temperature of 200° in an air bath. After two hours, the tube was washed out with water and the solution examined; but no trace of the pentoxide was detected. In the others, the temperature was raised to 250°, 290° and finally to a dark red heat; but with a similar result. By means of a Hofmann vapor density apparatus the mixture of oxygen and iodine was heated by aniline vapor to 192°, in presence of four beads of platinum sponge. Finally the mixture was sealed up in glass tubes with six beads of platinum sponge and heated for 6 hours to temperatures of 200°, 250° and 300°. But with no result, no pentoxide being detected as the product of the reaction. Since I_2O_5 decomposes at 300° it was not thought advisable to exceed this temperature.—*Ber. Berl. Chem. Ges.*, xvii, 2896, Jan. 1883. G. F. B.

4. *On the Atomic Weight of Platinum.*—Halberstadt has repeated the experiment of Seubert to determine the atomic weight of platinum from the double chlorides of potassium and of ammonium respectively, and has extended the investigation to the corresponding bromides and to platinum tetrabromide. Two methods of analysis were employed. In the first the platinum was determined by igniting the compound in a current of hydrogen and in the second by electrolytic precipitation. When potassium salts were used the results were checked by evaporating and weighing the solution of the residue. For the investigation 300 grams of platinum were used, purified by the Bunsen-Schneider method. The tetrabromide was obtained by heating platinum sponge with

bromine and aqueous hydrogen bromide in sealed glass tubes, evaporating the solution and heating the residue to 180°. It is a dark brown non-hygroscopic powder, difficultly soluble in water, easily so in alcohol and ether. The double bromides of potassium and of ammonium were prepared by adding potassium or ammonium bromide either to an aqueous solution of hydrogen-platinum bromide or to one of platinum tetrabromide. Ammonium-platinum bromide forms small crimson octahedrons difficultly soluble in water. The potassium solution is quite similar. The total number of determinations made was 97; 59 being by ignition and 38 by electrolysis. The mean result given by the former is 194·54246 for the atomic weight of platinum; by the latter 194·36073. The KCl and KBr determinations as checks gave in the former case 194·77061; in the latter 194·62987. Taking all the results the mean value obtained is 194·57592, the actual atomic weight of platinum.—*Ber. Berl. Chem. Ges.*, xvii, 2962, Jan. 1885. G. F. B.

5. *On the Preparation of Chromium oxychloride* (*Chromyl chloride*).—Moissan has observed that if chromium teroxide, free from sulphuric acid, be introduced into hydrogen chloride gas, this gas is at once absorbed and abundant red fumes are produced which condense into a liquid boiling at 108° and which are chromic dichlorhydrine. Heat accelerates the reaction. Hydrogen bromide and hydrogen iodide do not react under these circumstances. Chlorine if absolutely dry does not act on chromium teroxide; but in presence of moisture chromyl chloride is produced. The chromates of the alkalies, of barium, lead and silver yield the chromium oxychloride with HCl gas.—*Bull. Soc. Ch.*, II, xliii, 6, Jan. 1885. G. F. B.

6. *On certain new Paraffins.*—Sorabji has prepared in the laboratory of Wislicenus, some of the higher members of the paraffin series hitherto unknown. The reaction employed was that of Wurtz, which consists in treating the iodide of an alcohol radical with sodium. For this purpose cetyl iodide dissolved in six times its weight of ether was placed in a flask furnished with a return condenser. Finely divided sodium was then added and in a short time it became covered with iodide and the whole liquid was filled with glistening scales of dicetyl. After recrystallization from glacial acetic acid, they fused at 70° and distilled without decomposition at a much higher temperature. On treating heptyl iodide in the same way, diheptyl was obtained as a colorless mobile oil, boiling at 245° and solidifying at 6°. When a mixture of ethyl and of cetyl iodides was treated with sodium, ethyl-cetyl was obtained as a colorless oil, boiling at about 312°. Cetane was also prepared by the author, by reducing the iodide by concentrated hydrogen iodide solution in presence of phosphorus, and by digesting the iodide with zinc and hydrogen chloride. It is an oil which boils at 278° and solidifies at 18°–20°.—*J. Chem. Soc.*, xlvii, 37, Jan. 1885. G. F. B.

7. *On some Derivatives of Urea.*—Some time ago **Behrend** described a body obtained from acetacetic ether and urea with the loss of a molecule of water. Upon saponification the sodium salt was produced; but this on the addition of an acid gave an acid poorer by one molecule of water. Strong nitric acid attacked it converting the methyl group into carboxyl and nitrating the rest, giving a strong dibasic acid. This splits up giving a nitro-body $C_4H_3N_3O_4$, which when reduced gives $C_5H_6N_4O_2$, a body differing from xanthin by H_2O less and which gives the murexide reaction.—*Ber. Berl. Chem. Ges.*, xvii, 2846, Jan. 1885. G. F. B.

8. *A Treatise on the Principles of Chemistry*; by **M. M. Pattison Muir**, M.A., F.R.S.E. 488 pp. 8vo. Cambridge, 1884, (University Press).—This is a volume of much more than ordinary importance among recent contributions to chemical literature. Excellent books are not wanting in which chemical facts are presented, but a profound and thorough work upon Chemical Philosophy, suited to the wants of a student who has learned and digested these facts, has long been needed and this want is well supplied by the present volume. The subject is divided into two parts, Chemical Statics and Chemical Kinetics. Under the first are discussed the subjects of atoms and molecules, of atomic and molecular systems, the periodic law, and the applications of physical methods to problems of chemical statics. Under the second the leading heads are dissociation, chemical change and chemical affinity. The work is full of suggestive matter and will aid all students who are desirous of mastering the fundamental principles of modern chemistry. It is especially full in its references to recent work in the department of chemical physics.

9. *An Introduction to the Study of Organic Chemistry;* by **Adolph Pinner**, Ph.D., Professor of Chemistry in the University of Berlin; translated and revised from the fifth German edition by **Peter T. Austen**, Ph.D., F.C.S., Professor of Chemistry in Rutgers College. 403 pp. 8vo. New York, 1884, (John Wiley & Sons).—This is an excellent text-book of Organic Chemistry and cannot fail to be welcomed by instructors in this department; Professor Austen has done a good work in thus making accessible to students in this country a volume which has met with such marked success in Germany.

10. *The Elements of Chemistry, Inorganic and Organic*, by **Sidney A. Norton**, Ph.D., LL.D. 504 pp. 8vo. Cincinnati and New York, 1884, (Van Antwerp, Bragg & Co.)—This is an elementary volume designed as a text book, and presenting the fundamental principles and facts of chemical science in clear and orderly form. Numerous experiments, mostly of very simple character, are described which the student is expected to perform for himself.

11. *The possibility of basing a Kinetic Theory of Gases upon Attracting Force alone.*—Hitherto the hypothesis has been acted upon that there is a repulsive force between molecules—the hypothesis of elastic spheres being mechanically equivalent to the hypothesis of a repulsive force which for distances greater than

the sum of the radii of the molecules is equal to zero and for smaller distances increases to a great degree. **Boltzmann** remarks that Joule's research on the flow of gases without the production of work shows that between the gas molecules an attractive force must act. Boltzmann therefore considers the question whether the hypothesis of attracting force alone is a tenable one. He finds that Maxwell's formulas based upon the old hypothesis of repulsive force apply to the new hypothesis with suitable changes in the constants.—*Ann. der Physik und Chemie*, No. 1, 1885, pp. 37–44. J. T.

12. *Electrical Resistance of distilled water.*—**Friedrich Kohlrausch** shows that water distilled in a vacuum has a much greater resistance than ordinary distilled water which takes up gases which affect its specific resistance. He describes fully the apparatus by means of which he distilled water in a vacuum of $0 \cdot 01^{mm}$ of mercury pressure. In measuring the resistance of the water a galvanometer with quick moving needle was used in preference to a dynamometer with alternating currents. The galvanometer was more sensitive than the dynamometer or telephone, and polarization was avoided by depressing the battery key for an instant only and taking observations with reversed currents. The resistance of one ohm is represented by a layer of water 1 square millimeter in section and 26 billionths of a meter in thickness. The resistance of a column of water 1 square millimeter in section and 1 meter long is about $4 \cdot 10^{10}$ ohms. A copper wire of the same section and resistance would be $24 \cdot 10^{8}$ kilometers, which measures a distance through which it would take light 2·2 hours to travel.—*Ann. der Physik und Chemie*, No. 1, 1885, pp. 48–52. J. T.

13. *Double refraction of light in fluids.*—Double refraction has hitherto been noticed only in substances which possess an axis—and the refraction is closely related to the direction of this axis—or in substances submitted to a pressure in definite directions. **E. v. Fleischl**, acting upon the belief that a suitable combination of a right-handed circular polarizing liquid with a left-handed circular polarizing liquid might produce two wave-fronts which would give double refraction, constructed a long glass vessel which was divided by diagonally placed glass partitions. The glass tray thus resembled the arrangement of prisms in a direct spectroscope. The hollow prisms thus formed were filled on one side with a right-handed polarizing liquid and those on the opposite side with a left-handed polarizing liquid. A solution of levulose in water was used for the latter and ordinary right-handed sugar for the former. The arrangement of the apparatus was as follows: a small opening was made in a screen in front of a gas flame. The light from this passed through the train of prisms. About five meters from the latter was placed a telescope provided with an astronomical eye-piece which magnified 65 times. On looking through the telescope not one point but two were seen near one another. The appearance was like that of a well separated

double star; orange oil and mixtures of turpentine gave results similar to those obtained with sugar. The two images were shown to be polarized in different planes, and the author believes that he is justified in concluding that there are doubly refracting fluids which have no optical axes; and that circular polarization in liquids is due to this double refraction. The wave surfaces of light in these liquids consist of that of two concentric spheres.—*Ann. der Physik und Chemie*, No. 1, 1885, pp. 127–144. J. T.

14. *Penetration of day light in the water of Lake Geneva.*—MM. **Fol** and **Ed. Sarasin's** experiments consisted in exposing photographic plates at various depths in the lake. They used Monckhoven's rapid gelatino-bromide plates. The special apparatus consisted of a brass photographic holder, the slides of which were closed by a pair of levers joined like scissors, and actuated by a weight. These levers separate by means of a counter acting spring as soon as the weight of the lead in touching the bottom releases the spring. The plates were exposed a certain length of time in a horizontal position at a given distance below the surface of the water. The time of exposure was always ten minutes. The developer consisted of the normal oxalate of iron, which was used for ten minutes on each plate. The plates were all coated with the same emulsion. The experiments were made in front of Evian where the lake over a large extent is 315 meters in depth. It was found that day light penetrates into lake Geneva to the depth of 170 meters, and probably farther. At this depth the illumination in full day light is about that of a clear night without a moon. At 120 meters the light is still very strong. In September, in cloudy weather the light penetrates farther and with greater intensity than in perfectly bright August weather. This fact may be due to the difference in transparency of the water during these months or to the greater obliquity of the rays of the sun in September.—*Comptes Rendus*, Nov. 10, 1884. J. T.

15. *New Form of Daniell Cell.*—**Helmholtz** at the meeting of the Physical Society of Berlin, January 9th, describes the following modification of a Daniell cell. At the bottom of a deep glass goblet he placed a copper spiral which is connected with an insulated platinum wire in a glass tube. Above the spiral is placed a solution of sulphate of copper which could be replaced by means of a funnel reaching to the bottom. On the solution of copper lay the solution of white sulphate of zinc in which was placed the zinc cylinder. A siphon, the outer leg of which was directed from below upwards, dipped into the fluids as far as the bounding plane of the two fluids, so that, on filtering in a fresh solution, only the solution of white vitriol immediately above the blue copperas, and contaminated by it flowed off. This arrangement had the effect of keeping the upper fluid constantly water clear, though after a while some copper was found precipitated upon the zinc cylinder. The constancy of the cell was however not perceptibly impaired.—*Nature, January* 29. J. T.

16. *Researches on Solar Heat and its Absorption by the Earth's Atmosphere:* A report of the Mount Whitney Expedition, prepared under the direction of Major-General W. B. Hazen, Chief Signal Officer, by S. P. LANGLEY, Director of the Allegheny Observatory. 242 pp. 4to, with a map, twenty-one plates and wood cuts. Washington, 1884, (Professional Papers of the Signal Service, No. XV).—This volume contains a detailed account of the expedition of Professor Langley to Mt. Whitney in the Sierra Nevada, in 1881, and his observations undertaken in connection with it. The importance of the results reached by him as bearing upon solar and terrestrial physics can hardly be overestimated, and it is well to have the whole subject presented in full in a single volume; some of the leading conclusions of the expedition are presented in articles by Professor Langley in volumes xxvii and xxviii of this Journal.

17. *Tables, Meteorological and Physical,* by ARNOLD GUYOT, Ph.D., LL.D. Fourth edition, revised and enlarged, edited by WILLIAM LIBBEY, Jr. 738 pp. 8vo. Washington, 1884, (Smithsonian Miscellaneous Collections).—An interval of twenty-five years has passed since the publication of the last edition of Dr. Guyot's standard tables. The subject matter of the present edition was nearly finished at the time of the death of the honored author, about a year ago, and the final editorial work has been well performed by Professor William Libby, Jr. The volume appears now much enlarged and improved and fitted for even a wider sphere of usefulness in the country than it has filled heretofore.

II. GEOLOGY AND MINERALOGY.

1. *The Copper-Bearing Rocks of Lake Superior;* by R. D. IRVING—The editorial note on this subject in this Journal for January, 1885 (p. 67), gives a comparative statement of the views held by myself and Professor N. H. Winchell with regard to the Copper-bearing Rocks of Lake Superior, and the adjacent formations. It is shown therein that we are in general accord as to the mutual relation of these several formations, but differ as to their positions in the general geological scale. While Professor Winchell would make the Keweenaw series equivalent to the New York Potsdam, and the unconformably overlying fossiliferous sandstones newer than the Potsdam, I, on the other hand, would make the latter sandstones Potsdam, and the Keweenaw series pre-Potsdam. My object just now is to call attention to the paragraph of the note referred to in which it is said that Professor Winchell's argument, in favor of his position as to the Potsdam age of the Keweenaw series, drawn "from the fossils in the slates and sandstones of the St. Croix is indecisive, as remarked by Professor Irving, since the precise age of the fossils, whether Potsdam or later, is not certain. The Lingulæ of the sandstones of Taquamenon Bay, found by Rominger, which led him to refer those sandstones to the Potsdam, Professor Winchell says make the Keweenaw series Potsdam, *if* the rocks are equivalents."

With regard to the fossils of the St. Croix sandstones it is to be noted that their true Potsdam age has been maintained not only by Hall but also quite recently by Whitfield (Bulletin No. 5 of Am. Mus. Nat. Hist., also this Journal for April, 1884, p. 321) and Walcott (this Journal, Dec., 1883, pp. 439–442); so that we have now the very best of paleontological authority for this reference. Not feeling that I possessed sufficient familiarity with the fossils of the Primordial generally to justify my criticising Winchell's reference of those of the St. Croix sandstone to a higher horizon than the Potsdam, I was obliged in my discussion of the geological position of the copper-series (Copper-Bearing Rocks of Lake Superior, pp. 442–446) to accept his statements as to this point for the sake of the argument. But the opinions since announced by Walcott and Whitfield, who are familiar with all the newer paleontological material from the earlier Cambrian horizons, as well as with that upon which Hall based his conclusions twenty or more years since, seem to leave no room for doubt as to the true Potsdam age of the St. Croix fossils. The unconformable position of the Keweenaw series beneath the St. Croix sandstone being accepted, its pre-Potsdam age is thus rendered evident, as I have heretofore maintained, on other than paleontological grounds.

As to the Lingulæ of Taquamenon Bay, spoken of in the above quotation as found by Rominger, there is evidently a misunderstanding, since Rominger states distinctly that the Lingula found at Taquamenon River, was found in a loose fragment of a highly calcareous sandstone, mixed with the drift pebbles near the shore of Taquamenon Bay," and that "the calcareous nature of this specimen from Taquamenon River . . . . . points to" the Calciferous formation which here overlies the Lake Superior sandstone (Geological Survey Mich., vol. i, Part III, p. 80). He also says (*op. cit.*, p. 81) that the Lake Superior sandstones "have frustrated all my efforts to discover fossils in them;" and again (p. 80) that "there is no record of any instance in which recognizable fossils were found *in situ* in the Lake Superior sandstone." With regard to the sandstones *exposed* on the Taquamenon River (p. 84) he says, that they are wholly siliceous and non-calcareous, and that, therefore, they could not have afforded the fossil-bearing, calcareous fragments found loose on the shore of the bay. Of fossils in them, he could not find a trace.

Moreover, there is no question with any one except Winchell, so far as I know, that the Taquamenon River sandstones form part of the Eastern sandstone which he speaks of as in other places lying unconformably against the Keweenaw series, in which latter position he is, as I think, undoubtedly correct.

The Taquamenon River sandstone, therefore, affords no argument against the pre-Potsdam position of the Keweenaw series. The fossil-bearing sandstones of the St. Croix valley furnish good reason for believing in such a position.

Madison, Wis., January 12th, 1885.

2. *The Vertebrata of the Tertiary Formations of the West.* Book I; by EDWARD D. COPE. 1010 pp. 4to, with over 100 plates. Washington, 1883. Vol. III of the Reports of the U. S. Geological Survey, F. V. HAYDEN, Geologist-in-Charge. Published under the authority of the Interior Department.—This ponderous volume, by Professor Cope, adds another to the very valuable series of quartos published as the results of the Geological Survey under Dr. Hayden; "and the fourth volume which is to follow," says Dr. Hayden in his letter of transmittal dated Jan. 1, 1883, "may be regarded as a continuation of the present one, both comprising the material in the author's possession from the Cenozoic formations of the West." This volume III contains the Eocene faunæ (Puerco, Wahsatch and Bridger sections) "and the Lower and Middle Miocene (White River and John Day Faunæ), the Ungulates excluded; leaving to volume IV, besides these Ungulates, the Upper Miocene and Pliocene Faunæ. The report is a great contribution to American Vertebrate paleontology of high value. The most important of the results to science, among those of the volume, as enumerated by Professor Cope, are: discoveries of the Laramie genus *Champsosaurus*, and of *Plagiaulacidæ* in Tertiary beds; discoveries serving to illustrate five families and many genera and species of the *Creodonta;* the family *Periptychidæ* and its included genera; the families *Meniscotheriidæ*, and *Phenacodontidæ*; the suborder *Condylarthra;* the *Pantolambdidæ*, and the suborder *Taligrada*, and its applications in phylogeny; the *Anaptomorphidæ* of the Prosimiæ; the reconstruction of *Hyracotherium* and *Hyrachyus;* numerous *Marsupialia* from the Lower Miocene; besides the phylogenetic series of the Canidæ and Felidæ. The volume opens with a brief geological review of the Rocky Mountain Tertiary regions and stratigraphy, and then proceeds to its paleontological descriptions. The numerous lithographic plates are full of excellent figures.

3. *Contributions to the Fossil Flora of the Western Territories*, Part III: *The Cretaceous and Tertiary Flora;* by LEO LESQUEREUX. 277 pp. 4to, and over 60 plates. Volume VII of the quarto Reports of the U. S. Geological Survey of the Territories, F. V. Hayden, U. S. Geologist-in-Charge.—This is a second very valuable Report of the Hayden series issued within the past month. Mr. Lesquereux's previous volume, making volume VII of the series (bearing the date 1878) was devoted to the Tertiary flora of the Rocky Mountain region. The new volume is occupied with the Cretaceous, and additions to the Tertiary flora from the Laramie, Green River and Miocene beds. Besides, the author gives a revision of his former work on the subject under the new light afforded by more specimens, and recent publications on the fossil flora of other authors and regions, and tables showing the distribution of all the species, making this volume one of special value. The Dakota group, of the Middle Cretaceous, the source of the Cretaceous species, has had its limits extended by new discoveries, and now is known to occur at intervals from Kansas to

Colorado, an area 450 to 500 miles wide. The learned author remarks that the fact of the sudden appearance of the dicotyledons in the Cretaceous, and under numerous genera and species, throughout the northern hemisphere both in America and the eastern continent, is as yet inexplicable. "Nothing in the preceding strata," he observes, "indicates the decadence of the reign of gymnospermous plants, or shows any kind of difference which could lead one to presage the appearance of the dicotyledons." This vegetation has been traced from Greenland to Vancouver Island and along the Rocky Mountain region through Canada, to Colorado and Kansas, and in Europe to Germany, in about 40° north latitude.

The printing of this Report has been delayed much since its completion. The volume has been distributed during the month past. The title page bears the date 1883.

Lesquereux states that the species of the Dakota group, now over 150 in number, include only one conifer and one dicotyledon (*Populus primæva*) of the species described by Heer from the beds of Korne, Greenland, which this author refers to the *Lower* Cretaceous, but four conifers and eleven dicotyledons of those from the later beds of Ataue, Greenland, the latter belonging to the genera *Pinus*, *Sequoia*, *Winfeldia*, *Platanus* (P. Heerii) *Ficus*, *Sassafras*, *Diospyros*, *Andromeda*, *Cissites*, *Magnolia*, *Liriodendron* and *Sapindus*.

4. *Reports of the Tenth Census on Petroleum, Coke and Building Stones.* About 900 pages 4to, with numerous plates. Census office, CHARLES W. SEATON, Superintendent. Washington, 1884. —The reports included in this volume are: on the Production, Technology and uses of Petroleum and its products, by S. F. PECKHAM; The Manufacture of Coke, by JOSEPH D. WEEKS; Building Stones of the United States and Statistics of the Quarry Industry for 1880. The third report was originally in the hands of Dr. George W. Hawes; after his lamented decease, the work was continued by others and brought to completion under the supervision of Mr. Henry Gannett. All three reports are full of information of practical and scientific value on the topics of which they treat. The Report on Petroleum enters fully into the history of the industry in this and other countries; illustrates the distribution in this country by various maps and detailed descriptions, geological as well as topographical, treats of the technology and statistics of the subject, and all matter connected with the use of petroleum and its products; and closes with a long Bibliography. The subjects of Coke and Building Stones are presented with like thoroughness. The latter report contains an important chapter by Dr. A. A. Julien, on the subject of "The Durability of Building Stones in New York City and vicinity," which has a wide bearing in its facts and explanations.

The volume closes with a series of chromo-lithographs (from the establishment of Bien & Co.) representing various polished marbles, granites and other rocks, which are admirable; a volume of such plates, if as faithfully prepared, would be of great value to the Ornamental Stone industry.

5. "*Les Facies Géologiques*"; by Professor E. RENEVIER (Arch. Sci. Phys. et Nat. Geneva, Oct., 1884).—By "facies" Professor Renevier means a sedimentary formation that was made under special conditions of origin. This condition may be expressed in both the mineral, stratigraphical and paleontological features, and in whatever indicates whether a stratum or formation is marine, aerial or fresh-water in origin; if marine, whether of deep sea or shallow sea origin, sea-shore or off-coast; of open shore, bay or river-mouth origin; of exposed coasts or sheltered coasts; if of terrestrial origin, whether of ordinary fluvial, or extraordinary; of open lakes or of marshes; of salt-lakes, or brines, or fresh-water; of hot water or not; and so on. The author observes that in geological investigations, these points and others bearing on the object in view should be carefully considered. He gives reasons for the conclusion that the "flysch" of the Eocene is littoral in origin, and pronounces the flysch a "facies littoral." Under "formations subaériennes" he describes four facies, the *Crenogen facies*, resulting from mineral deposition like the geyser deposits: *Ossiferous facies*, surface accumulations of bones, or bone-breccias; the *erratic or glacier facies*; the *dune facies*. Other facies are recognized under other general conditions. The same geological formation will usually be of one facies in one place, and a different in another, and only the narrower subdivisions will ordinately be throughout of one facies.

6. *Floods in the Ohio River.*—A valuable paper on this subject by Mr. WALTER A. DUN, is published in the Journal of the Cincinnati Society of Natural History, vol. vii, No. 3, 1884. He sustains the view that forests have little influence over the height of the floods.

7. *Original Researches in Mineralogy and Chemistry*; by J. LAWRENCE SMITH, Membre Correspondant de l'Institut de France, etc. Edited by J. B. MARVIN, B.S., M.D. xl and 630 pp. 8vo. Printed for presentation only.—Twelve years have passed since a volume of the collected papers of Dr. J. Lawrence Smith was published. The volume now issued contains besides the papers in the former volume, the various important memoirs later published by him—his scientific activity ceasing only within a few months of his death. The volume opens with a biographical sketch prepared by Dr. MARVIN at the request of the American Academy of Arts and Sciences; a memorial sketch by Dr. MIDDLETON MICHEL, of Charleston, South Carolina, where Dr. Smith was long Professor of Chemistry; and a sketch of his life and scientific work by B. SILLIMAN, written for the National Academy of Sciences. It closes with a list of his published papers and notes, numbering in all one hundred and forty-five. The frontispiece is a faithful likeness of Dr. Smith, taken from that prepared for the J. Lawrence Smith gold medal of the National Academy, to which Professor Silliman alludes as follows in the closing paragraph of his just and highly appreciative address: "We rejoice that though dead he yet lives, and that the work he loved

so well will be perpetuated, under the auspices of the Academy, by a noble endowment bestowed *in memoriam* by his devoted wife."* The record of his researches and discoveries in the new volume will further make his energy a lasting source of progress to science.

8. *Fourth Annual Report of the State Mineralogist of California*, for the year ending May 15, 1884. 410 pp. 8vo. Sacramento, 1884.—Mr. Henry G. Hanks, the State mineralogist, has presented to the State of California, and to the mineralogical public, another large and valuable volume. It contains besides the report special, a chapter on the agricultural, commercial and manufacturing resources of the State, and a third giving a catalogue and description of the minerals of California, with special reference to those having an economic value. This catalogue extends to nearly 350 pages and describes 161 species, alphabetically arranged. The metals and mineral coal are mentioned in most detail. The volume opens with two excellent lithographs representing the San Bernardino meteoric iron.

9. *Minerals from Middletown, Conn.*, by W. N. Rice, (communicated in a letter to Prof. G. J. Brush, dated Jan. 17).—The following additional finds of minerals in this vicinity may be worthy of notice:—*Monazite*, at Hale's quarry, in northern part of Portland. A few of the crystals are of considerable size, the largest exceeding two centimeters in length. All the crystals show the planes *i-i*, *I*, 1-*i*; some of them show also 1, 1-*ì*, 2-*ì*. Crystals are of dull brownish red color and feeble luster. *Hyalite*, at same locality. The mineral fills cracks and lines cavities in the granite. It is stained by some impurity so as to show a delicate apple-green color. *Bismutite*, at Pelton's quarry, in eastern part of Portland. The two minerals are intimately mixed together, forming lumps of grayish green color. Microscopic examination serves to distinguish in the mass the white particles of cerussite effervescing with nitric acid, from the green non-effervescent particles of pyromorphite.

These minerals, with the three previously noticed—samarskite, rhodonite, Torbernite,—make a considerable addition to the already long list of minerals observed in our granite veinstone.

10. *Chrysoberyl in Maine.*—Mr. N. H. Perry, of South Paris, Maine, states that he has found chrysoberyl at Stoneham, also at Canton, Peru, Norway and Stow, but thus far not in fine specimens. Some of the small dark colored crystals in the fibrolite at Stoneham are however quite perfect in form. The small crystals occur at Canton and Stow with large coarse crystals.

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* See this Journal, III, xxviii, 77, 1884,

III. Botany and Zoology.

1. *Report on the Forests of North America;* by **Charles S. Sargent**, Arnold Professor of Arboriculture in Harvard College. Vol. ix of the Report of the Tenth U. S. Census. Washington, 1884. pp. 612, 4to, with 39 maps in quarto; also an Atlas of 16 elephant folio maps, illustrating distribution and character of forests.—A great work faithfully done. There are first a dozen pages of general remarks on the forests of the country as to distribution, touching upon its relation to rainfall, the distribution of the genera and of the species. This is followed by 220 pages (a full index included) of what is called a Catalogue of the Forest Trees of North America (exclusive of Mexico) with remarks upon their Synonymy, Bibliographical History, Economic Value, and Uses. The Catalogue is of course complete and is systematically arranged under the orders and genera; the bibliography really seems to be exhaustive, and the synonymy nearly so. The popular names follow, in a separate line and type. The geographical range is then given, occasionally with citation of authorities. Then the height of the tree and diameter of its trunk, in a general way. Finally the character of the wood is specified, including its specific gravity and the amount of ash.

Part II, The Woods of the United States, fills over 250 pages with the results of investigations (by Mr. Sharples) upon the qualities of the wood of the different trees, the specific gravity and ash, the fuel value, strength both tensile and under compression, etc., largely in the form of tables. A double quarto map exhibits the character of the fuel used in different parts of the settled country; another, with accompanying tables, illustrates the section on forest fires and makes their enormousness (we might write it enormity) manifest by showing what has occurred during the census year.

Part III takes up The Forests of the United States in their Economic Aspects, tabulates the lumber industry, illustrates descriptively and by colored maps the density and the character of the forests now standing in every State and Territory. The huge folio maps illustrate some of the data upon a larger scale than the more convenient ones intercalated in the letter-press. One of them shows the position of the forest, prairie, and treeless regions of the continent; another, the natural divisions of the forests; a dozen others are devoted to distribution of particular species of trees, being those of greatest economical value; and the last exhibits the relative average density of existing forests. The general index fills thirty pages, that of the Catalogue of the species and their synonyms, twenty more.

Evidently no labor nor pains have been spared. Considering the elaborate way in which the synonymy and the bibliography have been given, one must wish that a certain amount of popular botanical description had been added, either under each species or in synoptical characters under each genus. This, we know, it is intended to supply in another work, a popular Sylva, but the total absence of such matter here is conspicuous. Moreover, while the wood is characterized, the bark is unnoticed. The latter is often more characteristic than the wood, is more obvious, and is not rarely of equal or greater economical importance. The same may be said of the fruits. If as respects the botanical part, we have not the complete superstructure, we have a good foundation.

A. G.

2. *Macoun's Catalogue of Canadian Plants;* Part II. *Gamopetalæ.* Issued by the Geological and Natural History Survey of Canada, A. R. C. SELWYN, LL.D., F.R.S, etc., Director, Montreal; Dawson Brothers, 1884, pp. 193–394, 8vo.—Professor John Macoun, the indefatigable Botanist of the Canada Survey, brought out the *Polypetalæ* of this elaborate Catalogue early in the year 1883, in 192 pages, and now at the close of 1884 he adds the *Gamopetalæ.* Canada must here be understood in its extended sense of the whole British Dominion in North America, and even Alaska is included, scientific prevailing over political considerations. Geographical ranges and stations are given with fullness and critical particularity. A little longer delay in the printing of the Compositæ would have secured more uniformity in the nomenclature with that of the Synoptical Flora of North America. It was a long stretch to bring in *Arnica Sachalinensis,* Sachalin Island being indeed very far "off the coast of Alaska." Perhaps the present writer may be somewhat to blame for this, by not stating where the Sachalin or Saghalin, or Sagalin, is situated when he characterized that species. Professor Macoun may be quite right in the opinion that *Andromeda ligustrina* has been credited to Canada only through the unreliability of Pursh and the misconception of later botanists. But, as Carey and Washburn have collected it in Vermont, and as Oakes certified that Robbins found it as far north as Gardiner, Maine, it may well have reached the Canada line.

In respect to the extension of this name, Canada, which has so long had a definite meaning restricted to the two provinces, Upper and Lower, it seems to us as wrong as it is confusing to extend it across the continent and include in it British Columbia. Better make a new name if one is wanted, for the British Possessions in North America. A. G.

3. *Histoire des Sciences et des Savants depuis deux Siècles, précédée et suivie d' autres études sur les sujets scientifiques, en particulier sur l'Heredité et la Selection dans l'Espèce Humaine;* par ALPHONSE DE CANDOLLE, Associé étranger de l'Academie des Sciences de Paris, etc., etc.—This is a second edition, much enlarged and in some particulars changed from the first, which was published twelve years ago. It bears the date of 1885, but was issued toward the close of the preceding year. It discusses so many topics, and some of them with such particularity that a review, or even a full notice of the contents, of this stout octavo of

600 pages, will not be expected of us. Some idea of the varied interest of the volume may be gathered from our statement that, after three brief essays on the observation, first of material and then of social facts, and upon the best way to study statistics, we have a very full discussion upon the part which heredity, variability, and selection play in the development of the human species. At its close the author enquires whether the frequent tendency of civilized men to return toward barbarism is a matter of direct heredity or of atavism, and whether it is probable that civilization will some time completely perish off the earth. After this startling suggestion the author speculates scientifically upon the probable future of the human species.

The next essay, reprinted from the first edition with some changes, explains upon the principles of natural selection why contagious and epidemic diseases are more fatal at their first appearance among a people than afterwards, and how it is that vaccination may after long use come to be less protective than at first.

Then comes the article which gives its title to the volume, and fills more than half of it. It is an analysis of the lists of foreign members of the Institute of France, the Royal Society of London, and the Academy of Sciences at Berlin, for two centuries, and a discussion of the data in reference to the institutions of the countries and the races which furnished the savants, the influence of heredity, language, climate, etc., etc., and ending with deductions as to the causes and conditions which seem most to favor the development of the sciences, as well the moral, social, and historical as the mathematical, physical, and natural.

This is followed by the essay (which excited considerable attention on its appearance in the first edition), upon the advantage for science of a dominant language, and the expression of a well-reasoned opinion that the English language will be, and deserves to be, the dominant language of the twentieth century. In view of which the author alludes to the serious infirmity of our language, its loose and lawless orthography and pronunciation. There is also a short article on the different senses of the word Nature, and consequently of the words natural and supernatural, which does not go very deeply into the subject; and a new one upon transformations of movement in organized beings, plastic movements, vitality, etc. We notice that, although the author has no faith in the growing of mummy-wheat and the like, he thinks that the preservation of the vitality of a seed for two or three thousand years is not in itself improbable! A. G.

4. *Jahrbuch des Königlichen botanischen Gartens und des botanischen Museums zu Berlin;* herausg. Dr. A. W. Eichler, etc. Band III. 1884.—The third volume of this new annual, an 8vo. of 350 pages and with eight plates, thus promptly appears at the close of the year 1884, under the Director editorship, with the coöperation of Dr. Garcke, Curator of the Museum, and Dr. Urban, Curator of the Gardens. The principal editor begins the volume

by a brief account of the operations of the establishments under his charge. G. Volkens has a long article on the relations between the habit and anatomical structure in the organs of vegetation of plants. F. Johow discourses upon the biology of floral and extra-floral show-apparatus, i. e. the colored parts of or near flowers. E. Loew fills a large part of the volume with his observations upon insect-visitation of blossoms of plants in the open ground of the Botanic Garden at Berlin. K. Schumann investigates the etymology of the names and the history of Cloves; also the teratology of *Gagea pratensis*. M. Fünfstück has an illustrated paper on the development of Lichenes. Th. Wenzig gives a new synopsis of American Oaks. W. Schwacke writes upon the Curare arrow-poison of the Tecuna Indians, and gives a sketch of the flora of Manáos in Brazil. I. Urban brings together some Miscellanea upon plants of the Berlin garden. K. Prantl gives a systematic arrangement and notes upon the geographical distribution of the *Ophioglosseæ*. A. G.

5. *Origin of Cultivated Plants.* By ALPHONSE DE CANDOLLE. New York, D. Appleton & Co. 1885. pp. 468, 12mo, (The International Scientific Series, vol. xlviii).—We gave an elaborate review of this interesting volume in this Journal, upon the first appearance of the original French edition, three years ago. Its re-issue now in English, we are glad to know, will assure to it a wider circulation. The translator's name is not given; but he appears to have done his work well. In two or three paragraphs at the proper places the author refers to "the learned articles" in our pages. The erudition was supplied by Mr. Trumbull, whose stores of information respecting aboriginal cultivations in America we should be glad to draw upon more largely. A. G.

6. *Abnormal and pathologic forms of fresh-water shells from the vicinity of Albany, New York*, with two plates; by C. E. BEECHER (36th Rep. N. Y. State Mus. Nat. Hist.).—The abnormal forms which Mr. Beecher describes includes unusually expanded apertures in *Physa ancillata* Say and *Planorbis exacutus* Say, a heterospiral growth of the shell in *Gillia altilis* Lea, the shell having the first three volutions normal, and the spiral reversed for the last volution; a carination of the volutions and narrowing of the upper part of the aperture in *Somatogyrus subglobosus* Say; the last two volutions free in *Valvata tricarinata* Say; a sinistral form in *Planorbis exacutus* Say; and abnormal forms also in several Unios.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Memoirs of the National Academy of Sciences*, vol. II. 262 pp. 4to, with several plates. Washington, 1884.—This second volume of the Memoirs of the National Academy of Sciences recently issued, contains the following important papers: 1, Report of the Eclipse Expedition to Caroline Island, May, 1883; 2, Experimental determination of wave-lengths in the invisible pris-

matic spectrum, by Prof. S. P. Langley; 3, On the subsidence of particles in liquid, by Prof. W. H. Brewer; 4, On the formation of a deaf variety of the human race, by A. Graham Bell.

2. *The Watts Fund.*—The Committee having in charge the raising of a fund for the family of the late Mr. Henry Watts (see page 172 of the last number), announce that nearly £1500 have already been contributed in England; American chemists will doubtless be prompted to do their share in aiding this good work.

Transactions of the Vassar Brothers Institute, and its Scientific Section. Poughkeepsie, N. Y. Vol. ii. 1883–1884.—Among the papers in this volume there are the following: a notice of a bed of hematite in connection with Lower Helderberg limestone at Cold Hill (a secondary product), in Cornwall, Orange County, New York, by Professor W. B. Dwight; notes on the *Carcharodon carcharias*. with figures, by Dr. W. G Stevenson: on uniformity in climate in past geological ages, by C. B. Warring; on evidence of intelligence in butterflies, by J. M. DeGarmo; on paleontological discoveries near Poughkeepsie, by W. B. Dwight.

OBITUARY.

ALFRED TYLOR, Esq., of Carshalton, County Surrey, England, died on the 31st of December, in his sixty-first year. Mr. Tylor was an active geologist, member of the Geological Society of London. He contributed a number of memoirs as the result of much research, to the Society which are published in its Memoirs. The subject to which he was especially devoted was that of fluvial action, or river deposits and the conditions of their formation. On account of the great extent of the river terraces in the era following the glacial, and the excessive rains during the era which the terraces were believed by him to indicate, he named the era previously called in America, the Champlain period, the *Pluvial* period. Mr. Tylor was at the Montreal meeting of the British Association, and afterward visited various places in this country. He was a very genial man, overflowing with interest in his geological work, and also abounding in information on other subjects. He was a member of the Society of Friends.

ROBERT ALFRED CLOYNE GODWIN-AUSTEN, eminent among the older geologists of England, died on the 25th of November last, age 76.

Mr. Austen's papers are numerous and have had great effect on the progress of British and general geology. He was elected a Fellow of the Geological Society in 1830, and a Fellow of the Royal Society in 1849, and received from the Geological Society the Wollaston Medal in 1862. A review of his life and a list of his published geological works and papers is contained in the *Geological Magazine* for January last.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXXV.—*On the use of Carbon bisulphide in prisms; being an account of Experiments made by the late* DR. HENRY DRAPER *of New York.*[*]

THE photographs which were taken in the research on the presence of oxygen in the sun, in the earlier as well as in the later series of experiments,[†] were obtained by the use of two hollow prisms filled with carbon bisulphide. These prisms were loaned for this purpose by Mr. Rutherfurd, having been made by him for producing his celebrated solar prismatic spectrum.[‡] The photographic work for the oxygen research was done in New York in a back room of the third story of Dr. Draper's residence. The temperature of this room proved to be remarkably uniform, the quality of the photographs and especially the sharpness of definition, being all that could be desired. When however the preliminary experiments required for the continuation and extension of this research were undertaken in the new physical laboratory (which Dr. Draper had built above his stable in the rear of his house and which was completed in 1880) it was found practically impossible to use carbon bisulphide prisms in this room owing to the rapid variations of the temperature there. No definition whatever could be obtained with the same prisms which had performed so well in the main house. In consequence, the use of these prisms had to be abandoned and a series of experiments was made to obtain the spectrum by other means. First a Rutherfurd silvered glass grating of 8,640 lines to the inch was employed and subsequently a train of six flint glass prisms made by Steinheil and loaned by Mr. Rutherfurd. With reference to these experiments, Dr. Draper says: "The exposures required when using the silvered grating were so long that experimentation was very teious; but when in addition, the definition did not equal that of the two bisulphide prisms formerly used, a change became necessary. If we could overcome the effect of temperature on bisulphide it would doubtless serve our purpose best, because it is more transparent, less colored and loses less light by reflection than glass prisms since there are only two prisms needed to do the work of four flints. But the instability of a bisulphide train is so marked in the new laboratory on account of the fluctuations of temperature, that we have not been able to depend upon it. Possibly if the prisms were enclosed in cotton batting or immersed in water these difficulties might be overcome."

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[*] The results which were obtained by Dr. Draper in his investigations on the cause of the difficulties encountered in the use of carbon bisulphide in prisms seemed so valuable and so likely to be of service to others engaged in photographing the prismatic spectrum, that at the suggestion of several of his scientific friends it was decided to publish them. At the request of Mrs. Draper, therefore, and with her kind assistance, I have collected from Dr. Draper's copious notes the facts in relation to his experiments which are detailed in the following pages; and have also made some supplementary measurements to test the efficiency of the apparatus.—GEORGE F. BARKER.

[†] This Journal. III, xiv, 89, Aug. 1877; xviii 262, Oct. 1879.

[‡] This Journal, II. xxxv, 407, May, 1863; xxxix, 129, March, 1865.

With the flint prisms, the definition of the sun spectrum was excellent, but it was found impossible to get the line H on the photographic plate, through the train. The silvered glass grating permitted the spectrum from F to a long distance above H to be obtained at one exposure on an eight-inch plate; but the definition given by it on the sun spectrum was inferior to that obtained with the prisms. The definition of the flint train however, good as it was, only equaled and did not surpass that of the bisulphide prisms used in the oxygen research; "the rippled line below G is as well defined" Dr. Draper says, "as I have ever seen it with the two bisulphide prisms." On the spectrum of the carbon arc, the dispersion given by the train between G and H was double that given by the silvered grating in the spectrum of the first order; while that given by "the two bisulphide prisms between G and H is slightly greater than that of the six flint prisms." Moreover, while the definition on the lines of the sun spectrum was best with the flint prisms, that on the spark spectrum lines was best with the grating. These experiments extended through nearly two years, from March, 1880, until early in the winter of 1881–2.

Among the earliest experiments which were undertaken in the new laboratory was a series made to test the performance of a bisulphide prism of Thollon's construction* made by Hilger of London, and obtained from him by Dr. Draper when in Europe early in 1879. This prism consists of a glass bottle having two plane sides making an angle of 90° with one another, upon which are cemented two prisms of flint glass four by two inches on the face, having each a refracting angle of 18°. The refracting edges of these glass prisms are opposed to that of the bisulphide prism. Hence the refracting angle of the compound prism is 54°. The same difficulties were experienced with this prism as with the Rutherfurd bisulphide prisms. Owing to the temperature-variations, the spectrum lines were "wooly" and no definition was possible. Dr. Draper says: "The bisulphide prism touched with the finger or breathed on loses all definition at once." It was found however, that the dispersive power of the Thollon prism was equal to that of about four of the Steinheil flint prisms; and this fact, together with the unsatisfactory character of the results obtained with the train of prisms as well as with the grating, led Dr. Draper to undertake an investigation into the causes of this unsteadiness of the bisulphide, with a view to remedying it if practicable.

The same difficulty has been encountered by all experimenters who have endeavored to use bisulphide prisms. Mr. Rutherfurd himself found it to be very serious and M. Thollon says such prisms must be protected carefully from temperature-variations. It was while using these prisms that Mr. Rutherfurd made an important observation. He noticed that "if a good prism which with a high power refuses to define the soda line (a more stringent test than solar lines) is violently shaken and then placed in position, it will for a few minutes define beautifully but gradually settle into its former condition."† It occurred to Dr. Draper therefore, that possibly the striæ caused by convection currents produced by inequalities of temperature, and which caused the bad definition, might be destroyed by an active agitation of the liquid. Acting on this suggestion, on the 19th of November 1881 he placed a small propeller wheel in the bisulphide contained in the Thollon prism, its shaft passing out through the stopper. By means of a small electric motor, this propeller could be rotated with any convenient speed. The result was marvelous; by thus keeping the liquid in agitation all inequalities in its density were prevented and the definition became excellent. On the 21st of November, with the stirrer revolving five times a second the definition was so perfect that even with a faint flame the sodium line could be seen distinctly reversed. A series of comparisons was now undertaken between the train of Steinheil prisms and the Thollon prism as arranged with the stirrer. On December 2d, using sunlight, the relative dispersion of the two was found to be very nearly equal, the flint train giving perhaps one-eighth more; but the amount of light transmitted by the bisulphide prism was at least four times and in the region about G eight times as great as that obtained from the Steinheil prisms.

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* J. Phys., viii, 73, 1879. C. R., lxxxviii, 80, 82, 1879.

† Loc. cit., p. 130.

But now another source of error was developed. Although when the propeller was running, the definition of the bisulphide prism was not affected by changes of temperature, yet now, these changes of temperature, by changing the refractive index of the liquid, caused a continual shifting of the position of the lines in the spectrum, either in one direction or the other. It is obvious therefore, that during an exposure of any considerable duration, such as is often necessary with faint spectra, this change of position in the lines due to temperature-change would absolutely destroy the definition on the photographic plate. In the hope of correcting this new difficulty, an even temperature box was constructed about the prism, and was filled with cotton. On the morning of December 8th it was found that the thermometer had fallen during the night 9° F. and that the sodium lines had shifted toward the more refrangible end of the spectrum a distance of 0·75 inch.* A direct experiment, made by placing a thermometer in the bisulphide, showed that for a change of 3·75° F. a change took place in the position of these lines of 0·375 inch. The box containing the prism was then enlarged to 30 inches on a side and a plate of iron 6 inches square was let in to the bottom, and so arranged that it could be heated by a gas flame. Subsequently an iron tube closed at the upper end and nine inches long, was passed through the plate and allowed to project 7 inches into the box. The temperature within was regulated by two compound expansion bars made of strips of vulcanite and brass riveted together and included in the circuit of a battery and an electro-magnet so arranged that when the ends of the bars came in contact as the temperature rose, the circuit was closed and the electromagnet turned down the gas. When the temperature fell, the circuit was opened and the gas was again turned on. On the 16th of December, the regulator was adjusted for 77° F., the temperature of the room being 63° F. After four hours the sodium lines ceased to move toward the red, but, until the stirrer was started, the definition was bad and the lines could not be separated. On the morning of December 20th the thermometer in the box had fallen over night from 79° to 65° F. and the sodium lines had receded toward the violet end of the spectrum a distance of 1·375 inches. On turning on the heat, the prism did not appear to feel the effect for half an hour. Then the lines began to move toward the red end of the spectrum and continued to do so for more than five hours. On turning off the heat, the lines began to recede in half an hour; but although it was again turned on, they did not become stationary for an hour. On the 23d, the even temperature box was enlarged and a second box constructed within it, the space between the two being filled with cotton. On the 29th, the regulator was started at 7 A. M. At 1 P. M. the temperature became stationary at 70° F. and the spectrum remained at rest for two hours. On the morning of January 1st, 1882, the temperature of the box was 54° F., having cooled from 72° F. over night, and the sodium lines had moved a distance of 1·8 inches. From these experiments, the conclusion was reached that if a change of over 10° F. is to be made in the box, it is doubtful whether with this apparatus the spectrum can be made stationary on the same day. The heat was therefore left on over night and the temperature was found to be readily controlled the next day. There were fluctuations of course; but they were not enough to injure the definition if the exposure was not over 15 or 20 minutes. On the 25th of January some changes were made in the heating tube by placing a funnel upon its lower end, by continuing it up through the top of the box and by making an opening on one side of it within the box. A relay was also arranged with a damper so as to close the top of this tube whenever the circuit was broken by the separation of the differential bars in the box, and to open it when the circuit was closed. This relay acted in concert with the electromagnet above mentioned, closing the tube when the gas was turned on and opening it when it was turned off. On lighting the gas jet below the funnel, the heated air rises into the tube and passes into the box through the lateral opening in the tube. When the temperature is reached for which the bars are set, they come in contact and close the circuit. The electromagnet attracts its armature and thus turns down the gas while the relay also closes and thus opens the damper on the top of the tube. The heated air now passes out of the box through the lateral opening until the temperature has fallen sufficiently to separate the expansion bars and open the circuit. No experiments with this apparatus are recorded in the note-books.

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* These measurements were made by Mr. D. C. Chapman, who at that time was acting as Dr. Draper's assistant.

On the 27th of December, 1884, the apparatus was put in order and some experiments were made with it for the purpose of testing its efficiency. The automatic arrangement for regulating the heat was easily adjusted and found to work well. The definition of the sodium lines which at first was very bad, became admirable in a few moments after starting the stirrer. On the 30th, the first systematic test was made with it. The gas was lighted at 9 o'clock, A. M., and at 11 h. 20 m. the temperature of the box was 67·5° F. The cross wires of a small telescope were then set on the less refrangible component of the sodium line. In 15 minutes the other component was on the cross wires, the spectrum having shifted the distance between these sodium lines in this time. The displacement was toward the red, and the prism was rising in temperature. The second similar change in position required also 15 minutes; but the third required 19, the fourth 35 minutes and the fifth 49 minutes. A centigrade thermometer reading to tenths was then placed in the box. At 5 h. 25 m., P. M., this thermometer read 21·3° C. and the cross wires were set on the less refrangible sodium line. In 25 minutes the thermometer read 21·4° C. and the spectrum had moved over a little more than the distance between the components. A second change of this amount required 41 minutes, the thermometer showing no change. At 1 h. 2 m., A. M., the spectrum had again shifted by a distance equal to that between the components of the sodium line, but had required 97 minutes to accomplish it, the thermometer reading 22·3° C. at the beginning and at the close of the experiment. The latter part of the time the spectrum shifted by only the width of one of the components in an hour. In a second experiment, an hour and six minutes was required for this amount of displacement. The thermostat was then left in action over night. At 9 h. 10 m. the next morning the thermometer read 22° C. not having perceptibly changed since the last reading, while the sodium lines had shifted in seven hours by only a little more than the distance between them.

The gas was then turned off and the entire apparatus allowed to remain at rest for several days, the temperature of the box, the position of the sodium lines, and their definition being observed by Mrs. Draper from time to time. The following are the values obtained:

Date.	Time.	Temp. of Room.	Temp. of Box.	Definition.	Displacement.
Dec. 31st.	10 p.m.	68° F.	18·2° C.	Excellent.	1·25 inches.
Jan. 1st.	12 m.	69° F.	18·4° C.	"	1·166 "
"	3 p.m.	68° F.	18·6° C.	"	1·083 "
Jan. 2d.	10:45 a.m.	56° F.	13· ° C.	Good.	2·416 "
Jan. 4th.	12:30 p.m.	50° F.	9·6° C.	Fair	3·583 "
"	4:40 p.m.	"	"	Excellent.	3·583 "
(*Gas lighted in thermostat.*)					
"	7:30 p.m.	50° F.	15·2° C.	Entirely gone	2·083 "
Jan. 5th.	10:25 a.m.	50° F.	9·4° C.	Excellent.	----
(*Gas lighted in thermostat.*)					
"	10:30 a.m.	50° F.	10·2° C.	Fair.	----
"	10:45 a.m.	"	10·9° C.	Bad.	----
"	10:55 a.m.	"	12·2° C.	Entirely gone.	----
(Started the motor and in five minutes the definition was good. Put out the gas and a few minutes later stopped the motor. Definition lessened very slowly.)					
"	11:15 a.m.	50° F.	11·2° C.	Entirely gone.	----

The results which have been given in the preceding pages seem to have a two-fold bearing. In the first place they prove that by the simple expedient of stirring the liquid in a prism by means of a propeller or other device so as to keep it in active motion, all striæ due to temperature-changes may be prevented and the definition rendered perfect. Even carbon bisulphide, whose extreme mobility and high expansion-coefficient make it extremely sensitive to variations of temperature, may be made in this way to give the most admirable definition; so complete indeed, that in the spectrum given by such a prism, a fine reversed line has been seen in one of the components of the sodium line. The practical value of this simple device is very considerable. The Thollon bisulphide prism above mentioned while giving seven-eighths as much dispersion as six flint prisms gives four times the light in the entire spectrum and eight times the light in the region near G. For photographic purposes, now that the definition can be made permanently sharp and the shifting prevented, this prism must replace trains of glass prisms, and even gratings unless these are of large size and are used with telescopes of proportionately large apertures.

In the second place this investigation has called attention in a very marked manner to the change in refracting power with change of temperature. This subject has already been discussed with reference to liquids by several authors, especially by Gladstone and Dale* in 1858, and with reference to glass by Mendenhall in 1876,† and Hastings in 1878.‡ Both these physicists confirm the statement of Arago and Neumann that for glass the law is precisely the reverse of that given for liquids, and that the refractive index increases with the temperature. Mendenhall calls attention to the effect of this change upon the determination of the position of spectrum lines, especially with a train of prisms, and suggests that it may account for the discrepancies observed in the values given by different observers for the same line. In the case of the Thollon prism described in this paper, it will be observed that the deviation and consequently the refractive index increases in a very marked manner as the temperature diminishes; confirming Gladstone and Dale's law for carbon bisulphide. When the prism was cooled from 22° C. to 9·6°, the double sodium line moved toward the violet end of the spectrum over a distance of

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* Phil. Trans., 1858, 887.

† This Journal, III, xi, 406, May, 1876.

‡ Ibid. III. xv, 269, April, 1878. Hastings calls attention to the new and noteworthy fact, brought out by his results, that the variation in dispersive power attending variation in temperature is relatively enormously greater than that of the refractive power.

3·583 inches.* As Mendenhall has shown that no change takes place in the angle of a glass prism with change of temperature, it follows that the flint glass prisms composing the sides of the Thollon prism change only in their specific refraction with change of temperature. Hence the change of the refractive index observed in this prism as above stated, is a differential result due to the excess of the change in the index of the bisulphide in one direction, over that of the flint glass in the other.

Moreover it has now been most clearly shown that by means of a suitable thermostatic arrangement, it is quite possible to preserve the temperature of the prism so uniform that no material change of position shall take place in the spectrum lines, at least during any reasonable exposure. The numerical results above given prove that in the apparatus as arranged by Dr. Draper the temperature did not vary 0·1° C. for more than seven hours, and that during that time the sodium lines did not change their position by an amount equal to the distance between them. Hence this source of difficulty, hitherto so serious in spectrum photography, especially when the exposure is a long one, is entirely obviated.

These experiments, moreover, confirm the opinion that the irregularities in the bisulphide which are the cause of its bad definition, are produced by an inequality between the temperature of the liquid and that of its enclosing vessel, thus producing convection currents in the liquid. So long as the temperatures of the prism and of its contents rise and fall together, and with the surrounding objects, so long the definition remains perfect, notwithstanding the temperature change. It is only when considerable changes of temperature take place suddenly, that the striæ due to these convection currents appear and spoil the definition. As this is the condition in most working laboratories, the advantages there of a method of completely obviating the evil by agitation enables the experimenter to secure good definition with any changes of temperature. But now these changes of temperature, though they cannot produce bad definition, do cause shifting of the lines. The even temperature box already described cures this trouble completely. When this box has been at a constant temperature for a sufficient time, the definition is good even without the stirrer. Even when the temperature of the box is changing quite rapidly, good definition can be always secured by starting the stirrer.

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* In the earlier series of experiments the change in position of the Na lines was very closely 0·1 inch for one degree Fahrenheit. In the later series, it was almost exactly 0·3 inch for one degree Centigrade. The results of the two series cannot be compared together owing to a change in the adjustment of the apparatus during the interval.

It will ever be a source of profound regret to the many friends of Dr. Henry Draper that he did not live to complete the research to which the foregoing investigation was preliminary. With his new and admirably equipped laboratory, and with this powerful and thoroughly corrected photographic spectroscope at his command as one of its first fruits, no one can doubt that he would have secured with it results of the highest value to astronomical, and especially to solar, physics.

ART. XXXVI.—*The Genus* Pyrgulifera *Meek, and its Associates and Congeners;* by CHARLES A. WHITE.

THE molluscan fauna of the Laramie Group of Western North America has a remarkable uniformity of character throughout its known geographical extent, from Mexico to British America, with the important exception of a region lying in Utah and Southwestern Wyoming. The strata of this region are underlaid and overlaid respectively by the equivalents of the same formations which underlie and overlie other parts of the Laramie Group, wherever such contacts are known. They are therefore referred to the Laramie Group although they hold a different molluscan fauna which, in my publications, I have usually designated as the Bear River Laramie, to distinguish it from the fauna of the greater part of that extensive group.

This Bear River Laramie fauna contains not only types of mollusca which are not found in that of the principal part of the Laramie Group, but which are not known among any other North American fauna, either fossil or recent; and, what is still more remarkable, a fauna which nearly approaches it, as regards the types referred to, is now living in Lake Tanganyika, Africa.

The molluscan fauna of this lake, whose waters are almost entirely fresh, has been published by Messrs. S. P. Woodward,* Edgar A. Smith † and H. Crosse.‡ Some of the forms are

* Woodward, S. P. On some new Fresh-water shells from Central Africa. Proc Zool. Soc. Lond., 1859, pp. 348–350, pl. xlvii.

† Smith, Edgar A. Diagnoses of new shells from Lake Tanganyika and East Africa. Ann. and Mag. Nat. Hist., (5) iv, 1880, pp. 425–430. On the shells of Lake Tanganyika and the neighborhood of Ujiji, Central Africa. Proc. Zool. Soc. Lond., 1880, pp. 344–352; pl. xxxi. On a collection of shells from Lakes Tanganyika and Nyassa and other localities in East Africa. Proc. Zool. Soc. Lond., 1881, pp. 276–300, pl. xxxii–xxxiv. Description of two new Species of Shells from Lake Tanganyika. Proc. Zool. Soc. Lond., 1881, pp. 558–561; two wood-cuts.

‡ Crosse, H. Faune malacologique du Lac Tanganyika. Journal de Conch., Paris; April, 1881, pp. 105–139, pl. iv. Supplement à la Faune malacologique de Lac Tanganyika. Same Journal, October, 1881, pp. 277–306.

like those which characterize fresh waters elsewhere, such, for example, as Unio, Planorbis, Limnæa, etc.; and some are of peculiar types belonging to fresh-water families, which types are found only or mainly in Africa. But a remarkable feature of this fauna consists in a few types which are so closely like some that are characteristic of marine faunas as to suggest that they have survived the gradual freshening of the lake from a former condition of marine saltness. Two species of one of the generic forms especially, are so nearly like *Trochus* that if they were found among a marine fauna would doubtless be referred to that genus. Mr. Smith has described these as belonging to a new genus, under the name of *Limnotrochus*. Another species which has much the aspect of a marine shell, is the *Melania* (*Sermyla*) *admirabilis* of Smith; but one of the most interesting generic forms of this Tanganyika fauna is the one to which Mr. Smith gave the subgeneric name of *Paramelania*. He described two species under this name, *P. Damoni* and *P. crassiangulata;* and M. Crosse (loc. cit.) referred an associated species, the *Melania nassa* of Woodward, to the same generic group. These seemed to me to be so closely like the *Pyrgulifera humerosa* of Meek, from the Bear River Laramie beds, that I published a note in Nature* expressing my belief that the African and American forms are congeneric; and I afterward republished that opinion with illustrations of both fossil and recent forms.†

In my article in Nature I also called attention to the similarity of *Melania* (*Sermyla*) *admirabilis* Smith, with *Goniobasis Cleburni* White. I might also have mentioned that the surface markings about the beak and front of *Unio Horei* Smith, also from Lake Tanganyika, are considerably like those of *U. belliplicatus* Meek, of the Bear River Laramie fauna. It thus appears that, including this *Unio*, there are three molluscan types in the Laramie Group which are apparently closely related to forms now living in Lake Tanganyika. The most conspicuous of these is the *Purgulifera* of Meek, of which I regard the *Paramelania* of Smith a synonym.

An interesting paper has lately appeared from the pen of Dr. Leopold Tausch,‡ in which he also places the three Tanganyika forms last referred to, under the genus *Pyrgulifera* of Meek, which genus he regards as nearly related to *Paludomus* Swainson. He also announces the discovery of Meek's type-species, *P. humerosa*, in the Upper Cretaceous fresh-water deposits of Hungary; and describes as new four other species of *Pyrgulifera* which he finds there associated with it. Besides these, he refers the *Melanopsis Pichleri* of Hoernes, the *M. armata* and *M. lyra* of Matheron, and the *Turbo acinosus* of Zekeli, all from the Upper Cretaceous of Europe, to *Pyrgulifera*. Thus, according to Dr. Tausch, there are twelve known species of this genus, nine fossil and three living; the latter in Africa exclusively; the type-species only, in North America; and nine in Europe, including the identified type-species there.

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* White, C. A. Tanganyika Shells. Nature; vol. xxv, 1882, pp. 101–102.

† White, C. A. New Molluscan Forms from the Laramie and Green River Groups, with discussions of some associated forms heretofore known. Proc. Nat. Mus., vol. v, pp. 94–99, pl. iii. A Review of the Non-Marine Fossil Mollusca of North America. Third Ann. Rep. Director U. S. Geol. Survey, pp. 403–550, pl. 1–32.

‡ Tausch, Dr. Leopold. Ueber einige Conchylien aus dem Tanganyika-See und deren fossile Verwandte. Sitzb. der k. Akad. der Wissensch., Band xc, Juli, 1884, pp. 56–70, plates i and ii.

Some doubt may be naturally felt as to the genuineness of the identification of *Pyrgulifera* among the living African fauna, as well as that of *P. humerosa* in the Hungarian Upper Cretaceous; but the identification of both seems to be as complete as such determinations can usually be made by means of the shells alone. If it is permissible to establish genera and species among fossil shells at all, we are entitled to hold those genera and species against anything except proof of error in diagnosis.

Admitting these identifications to be correct, the geographical distribution and chronological range of these shells are quite remarkable. They appear to have all been denizens of fresh, or at most, brackish waters, the geographical range of the faunas of which seems necessarily to be more restricted than that of marine faunas may be. Their distribution is all the more remarkable if Dr. Tausch's identification of *Pyrgulifera humerosa* in Hungarian strata is correct. The genuineness of the generic identification of *Pyrgulifera* in the American and European fossil, and the African living, faunas respectively, receives support from the fact that in each case some of the associated forms are similar. I have already mentioned the close similarity between *Goniobasis Cleburni* of the Laramie Group, and *Melania* (*Sermyla*) *admirabilis* of the Tanganyika fauna. Dr. Tausch also calls attention to the existence of *Fascinella* Stache in the Upper Cretaceous of Hungary, and shows that the Hungarian fossil shell is closely like the one living in Lake Tanganyika which Smith has described under the name of *Syrnolopsis lacustris*.

In North America, *Pyrgulifera humerosa* and its branchiferous associates appear to have been both geographically and chronologically restricted. In fact we yet know nothing of the previous, subsequent or contemporary history of the Bear River Laramie fauna; for its distinguishing types are not found either living, or in Tertiary strata and, as before remarked, they did not extend into the principal portion of the Laramie Group.

The cause of this marked difference between the faunas of the two portions of the Laramie Group I suppose to have been connected with their origin and development in two separate hydrographic basins, which probably existed contemporaneously, but separated from each other by a land barrier. I have suggested (loc. cit.) that the molluscan fauna of the greater part of the Laramie Group has descended to the present time through a perpetuation of the outlet drainage of the Laramie sea, now become a part of the Mississippi river system where a large part of the same types still live. The types of the Bear River Laramie fauna have not, as a rule, survived in North America. This I have thought was probably due to a failure of the outlet drainage of the waters in which that fauna lived to become perpetuated, in consequence of some subsequent geological changes, which necessarily destroyed its branchiferous fauna, with its peculiar types.

If we accept such views as this and still admit the real genetic relationship of the American, European and African forms which have been referred to, it is difficult to understand how their wide geographical distribution has been effected, and how they have been perpetuated to the present time. An interesting question for paleontologists to consider also presents itself in this connection, which relates to the assumed equivalency of formations which bear similar faunas. There are other reasons than the similarity of faunas why we should regard the American and Hungarian formations which contain *Pyrgulifera* as of approximately the same geological age. But so far as the Tanganyika shells which resemble the fossil forms referred to are concerned, the living fauna of that lake has an interesting homotaxial relationship with those fossil faunas of Europe and America which contain the shells that have been referred to the genus *Pyrgulifera.*

ART. XXXVII.—*On the occurrence of Native Mercury in the Alluvium in Louisiana;* by ERNEST WILKINSON, Ensign U. S. Navy.

NATIVE mercury has been recently discovered in a locality where its presence has hitherto been unsuspected. At "Cedar Grove" Plantation, in Jefferson Parish, Louisiana, on the west bank of the Mississippi, ten miles above New Orleans, native mercury occurs in small globules disseminated through the alluvial soil. These globules vary in size from a microscopic pellet to a BB shot, used for sporting purposes. They seem to be thoroughly admixed in the soil, and although more abundant within a limited area, are found for a distance of 1,200 feet. Beyond this distance, the limited time at my disposal did not allow me to investigate, but the appearance of the soil seems to indicate that the metal is gathered around a certain center and gradually disappears as the distance from this center increases.

The apparent center lies about 300 feet from the Mississippi River in an orange orchard, where also a number of live oaks are in luxuriant growth. The presence of this mercury has been noticed for a number of years, during the operations of plowing and ditching, but has never, to the writer's knowledge, been officially reported to the scientific world.

The writer took two negro men, with spades, to the locality and obtained several specimens of the soil one to five feet below the surface. He also washed out on the spot, from a small wash-tub full of earth, about two or three ounces of the native element. An analysis of two triturated specimens of the half-dried earth was made with the following results:

1.	Weight of soil,	500 grms.	Wt. Hg,	1·4652 grms.		%0·0029+
2.	" "	500 "	"	1·4687 "		0·0029+
	Total,	1 kilogram.	Total,	2·9339	mean,	%0·002934

Giving a mean percentage of mercury of 0·002934 per cent.

The soil is all alluvial and for a depth of 25 feet is as follows:—

1. Surface, mercury-bearing stratum, six feet thick. A sandy soil containing blue clay and vegetable mould.
2. Stratum of blue clay 6½ feet thick.
3. Similar stratum to surface, but containing no mercury, six feet thick.
4. Stratum of blue clay 6½+ feet thick.

It is not known how much deeper the fourth stratum extends. In none but the upper stratum of alluvial soil does mercury occur in sufficient quantity to be perceptible to the naked eye.

The large quantity of mercury, the great area over which it is scattered, the situation *above* the most frequented resort of commerce, the protection from overflowing by levees, and the absence of any appearance or history of any large cargo of mercury being wrecked in that vicinity, make it extremely improbable that such results could have been effected by the agency of man.

ART. XXXVIII.—*The Earthquakes in Spain;* by C. G. ROCKWOOD, JR.

THE series of earthquakes which has recently devastated the southern part of Spain, began with a disastrous shock at 8^h 53^m P. M., on December 25, 1884.

It had been preceded by a light, but somewhat widely extended shock in the early morning of December 22, which was felt on the northwest coast of Spain and in Portugal, and reached so far under the Atlantic Ocean as to affect Madeira and the Azores. The shock of December 25, has also been followed by a long series of oscillations, repeated at first several times a day, during the rest of December, and with gradually diminishing frequency through the months of January and February, 1885.

The shock on the evening of Christmas day, much the most violent of the series, caused great loss of life and destruction of property. Its influence was plainly felt as far north as Madrid, where bells were rung and clocks stopped, and very slightly also in England; but it was in the southern provinces of Spain, bordering on the Mediterranean Sea, that the greatest damage occurred. In Cadiz, Seville, Cordova, Jaen, and Almeria it was strongly felt, although causing no very serious damage in these places; but within the area defined by this chain of cities and the Mediterranean Sea, many towns and villages were left in a more or less ruined condition. In Granada, of the 10,000 houses composing the city, at least 7,000 will need repairs. The façade of the cathedral was injured. The inhabitants left their homes by thousands, and either camped for days in the open fields or emigrated from the city entirely. The famous Alhambra fortunately escaped injury. The villages of Arenas del Rey, Albuñuelas, Santa Cruz, Zaffaraya, and Alhama were destroyed. The latter place was built partly upon and partly at the foot of a bluff, and the upper town was shaken down upon the lower. overwhelming 1000 houses and 350 of the inhabitants. Here also the hot springs ceased to flow, and after two days began again with increased quantity and augmented temperature, the waters also having acquired a sulphurous character which they had not before possessed.

In Malaga all the public buildings were more or less injured. At Estepona a church and buildings were thrown down. At Torrox twenty-six shocks occurred between 8^h 50^m P. M. of the 25th and 11^h A. M. of the 26th, completely destroying the town. At Nerja the first shocks were followed by a hurricane which blew down many of the already weakened houses. At Almuñecar twelve shocks occurred in fifteen minutes. At Periana, a landslip overwhelmed a large part of the town, destroying a church and 750 houses. At Guevejar, a great semi-circular crevasse has surrounded the town on its upper side and the village, which rests on clay strata, is slowly sliding downward to the bed of the river Cogollos, some of the houses having already moved 27 meters up to January 16.

The provinces of Granada and Malaga have thus been the scene of the greatest destruction. Official reports up to January 14, state the number of persons injured in Granada as 695 killed and 1480 wounded. Other accounts estimate the entire loss of life as upwards of 2000. Thirty-five villages are named where a greater or less number of victims were taken from the ruins.

As bearing on the possible connection of earthquakes with atmospheric phenomena it is noted that an unusually high atmospheric pressure prevailed over the Spanish peninsula during the first-half of December, while on December 20, a heavy storm, attended by unusual depression of the barometer, struck the northern coast, and passing southward, reached the Mediterranean Sea on December 22, just previous to the great earthquake.

The geological relations of this earthquake may be seen from the following extract from remarks of Mr. J. MacPherson to the Spanish Natural History Society, reported in Nature (vol. xxxi, p. 278).

"A study of the Mediterranean watershed of Andalusia will show the existence of two great mountain masses, chiefly formed of archaic deposits. One of these is known by the name of the Serrania de Ronda, and the other by that of the Sierra Nevada. Both run in a series of folds and faults from southwest to northeast, and between them there lies an interval filled up with palæozoic, secondary and tertiary deposits. Toward the middle of this interval there rises up like an island in the midst of these later deposits, a series of ridges running from northwest to southeast, and formed of archaic rocks. They are known by names of the Sierra Tejea and Sierra Almijara, and the folds of these ranges, as in the case of the other archaic formations, run from southwest to northeast. It is clear, therefore, that this intermediary mountain mass is a segment of a more considerable archaic formation, separated from adjacent rocks through the subsidence of the ground on both sides. Owing to constant oscillations, this detached portion has been covered with the thick mantle of sediment which now overlies it, and its structure is easily accounted for as the result of that great fracture which crosses the peninsula from northwest to southeast, and in the prolongation of which lies the region now described. . . . . . .

" . . . The most violent shocks of the earthquake of December 25, were experienced in the region intervening between the Sierra Nevada and the Serrania de Ronda, and precisely on the very belt which enclosed the archaic mass of the Sierras Tejea and Almijara. That part of Andalusia, broken and torn by the secular disturbances of our globe, has proved naturally the weakest, and has, therefore, been the most exposed to the shocks from which Andalusia has so terribly suffered."

The Spanish government has appointed a commission, under the presidency of Sr. D. Manuel Fernandez de Castro, to study the phenomena of this series of earthquakes; and the Paris Academy of Sciences has also sent out a commission on a similar errand, under the lead of M. Fouqué, Professor of Geology in the Collége de France. The former has already issued an exhaustive list of questions, and most interesting and valuable results may be expected from the labors of these commissions.

Princeton, N. J., March 6, 1885.

ART. XXXIX.—*On Devonian Spores;* by J. M. CLARKE.

THE name *Sporangites Huronensis* was proposed by Sir J. W. Dawson in this Journal, April, 1871, p. 257, for minute, flattened, disc-like bodies occurring in abundance in the bituminous shales of Kettle Point, Lake Huron, rocks then regarded by Dr. Dawson of the age of the Marcellus epoch of New York, but referred to the "Upper Devonian" by Orton (this Journal, 1882, vol. xxiv, p. 174). These bodies were looked upon as spores or spore-cases of *terrestrial* acrogens, and this name has been applied to all such spore-like bodies wherever noticed in the Devonian rocks of North America.

Professor Edward Orton has noticed the occurrence of the same in the Devonian and Sub-carboniferous rocks of Ohio ("A Source of the Bituminous Matter in the Devonian and Sub-carboniferous Black Shales of Ohio," loc. cit., p. 171).

Professor H. S. Williams reports similar bodies from the Hamilton Shales of New York (quoted by Dawson, Proc. Am. Ass. Adv. Sci., 1883, "On Rhizocarps in the Palæozoic Period.") They are also found to be common in the black shales of the Marcellus and Genesee epochs in Ontario and adjoining counties of New York.

Dr. Dawson, in 1871 (op. cit.), suggested that these bodies were the fruit of Lepidodendron, possibly of the species *L. Gaspianum* and *L. Veltheimianum*, which occur at the same horizon. Professor Williams's specimens were associated with the plant *Ptilophyton Vanuxemii.* Dr. Dawson also mentions "rounded spore-like bodies in association with the stems of *Trochophyllum* of Lesquereux, from the lower Carboniferous of Pennsylvania." In the Marcellus beds of Ontario county they occur with *Psilophyton* sp., and in the Genesee Shales with *Cyclostigma affine* Dn. and *Lepidodendron Gaspianum* Dn. From my observations, however, plant remains in rocks containing *Sporangites Huronensis* are extremely rare, the fossils usually accompanying them being invertebrate marine species.

At the Minneapolis meeting of the A. A. A. S., 1883, Dr. Dawson, in the article already referred to, viz: "On Rhizocarps in the Palæozoic Period," suggested the probability of the spores or spore-cases representing the species *Sporangites Huronensis*, having been the fruit of some acrogenous plant of aquatic habit allied to the *Salvinia natans* of European rivers, and following this described forms accompanied and contained by spore-cases, for which was erected the provisional genus *Protosalvinia* with two species, *P. Braziliensis* and *P. bilobata.*

These species were found in material collected by Mr. Orville Derby, of the Geological Survey of Brazil, and are reported to be associated with the fucoid plant Spirophyton.

The reasons for the new interpretation of the relations of these bodies were (1) the occurrence of aquatic invertebrate fossils more or less abundantly in beds containing spores; (2) the existence of sporocarps containing spores and their close similarity to those of the existing Rhizocarps represented by *Salvinia natans* and others.

Of the vegetative portions of the plants producing these spores nothing is positively known. Dr. Dawson has given reasons for believing the species of Ptilophyton to have been aquatic in habit, and allied in fructification to the Rhizocarps.

During a series of years many specimens of Devonian rocks bearing spores have come into my hands from the Corniferous, Marcellus and Genesee horizons in the county of Ontario, N. Y. In the bituminous shales of the Marcellus and Genesee these are usually flattened, similar in mode of preservation to the specimens described by Orton from Kingsville, Ashtabula county, Ohio, and by Dawson from Kettle Point. The calcareous beds of the Corniferous and Marcellus preserve the spores with but little or no distortion, and specimens recently discovered in the latter horizon retain both macrospores and microspores, free and scattered, or within their sporocarps, conserving also the structure of both sporocarps and spores in a favorable condition. I have prepared this brief paper in order to show the structure of these bodies, and for present purposes they may be divided into *flattened* and *unflattened* spores, as only the latter show traces of structure.

FLATTENED SPORES.—*Sporangites Huronensis* Dawson.

In the Genesee rocks the spores, as far as observed, are always in this condition, but are not common. The bituminous shales of the Marcellus are often crowded with masses of spores of the same size and appearance as those of the Genesee. In their flattened condition they measure about one-third of a millimeter across, in substance consisting of a thin black carbonaceous film, which, by transmitted light, is of a deep orange hue. Specimens from Ohio, kindly sent me by Professor Orton, are similar in shape but somewhat larger and of a light amber yellow. Dawson's specimens from Kettle Point were also of a light yellow. These bodies, as well as those belonging to the first two of the subdivision following, I should regard as macrospores and not as sporocarps.

UNFLATTENED SPORES.

These divide themselves into three groups.

1. *Sporangites Huronensis* Dawson.

Occur in the Marcellus Shales in association with the flattened spores mentioned above. External coat thin, black, showing no structure. Interior filled with clear crystalline calcite, which, in the thin slices, shows strikingly against the black background of bituminous mud. These are very abundant in certain localities, markedly so in the loose bowlders of the Marcellus shaly limestones scattered through the towns of Canandaigua and East Bloomfield, and especially common in the Woodlawn Cemetery in the former place. At but one spot, viz: Padelford's, in the township of Canandaigua, on the N. Y. C. R. R., have rocks been found *in situ* which bear these spores, and there only sparsely. With them occur the fossils, *Leiorhynchus limitaris* Vanux., *Chonetes mucronata* H., *Productella truncata* H., *Leiopteria laevis* H. (Goldfs. ?), the characteristic invertebrate fossils of these rocks, and the only plant known here is *Psilophyton.*

2. *Sporangites Huronensis ?*

In the loose bowlders from the Corniferous limestone on Mud Creek in the town of East Bloomfield, occur spores which preserve a thick dense outer coating not resolvable into distinct cells. In the slices this external wall seems densest at the periphery and on the interior surface, on both surfaces limited by a black carbonaceous line. Between the two surfaces the substance is compact and has a granular appearance. The external wall has one third the thickness of the spore. The interior cavity is filled with crystalline calcite. In association with these are many somewhat smaller and often slightly flattened spores, from which most of the external wall has been removed, leaving only a single thin carbonaceous layer. Many of these forms, which seem to have lost most of the external wall, show, in the interior filling of calcite, splotches or filaments of bituminous matter, remnants of the organic substance with which the cavity was originally filled. Usually at a nucleus-like spot at or near the center, the calcite has, in crystallizing, oriented itself differently from that of the surrounding space, which leaves the impression that this spot may represent the original internal cavity of the spore. These bodies measure from one-third to one-half a millimeter in diameter, and are all macrospores. No microspores have been found and no satisfactory evidence as yet of sporocarps.

3. *Sporangites* (*Protosalvinia*) *bilobata* Dawson, 1883.

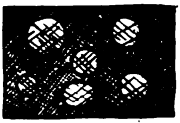
"Sporocarps, oval or reniform, three millimeters to six millimeters in diameter, each showing two rounded prominences at the ends, with a depression in the middle, and sometimes a raised neck or isthmus at one side connecting the prominences. Some of the specimens indicate that each prominence or tubercle contained several macrospores. At first sight it would be easy to mistake these bodies for valves of *Beyrichia*."—Dawson, *op. cit.*

From an examination of scores of slices of the rock containing these bodies, I find that they occur alone, that is unmixed, with the forms already described, and as far as observed, without other fossils.

Sporocarps.—These measure from two-thirds to one millimeter in greatest diameter, being thus considerably smaller than Dr. Dawson's specimens. In general contour and outline they are so strongly suggestive of Beyrichia or Primitia as certainly to mislead in macroscopic characters.

A single deep pit situated usually medially and slightly to one side divides the body into two prominences, which are slightly unequal. The larger of these may have on one side a smaller and shallower depression, making thus the number of prominences sometimes three. As far as observed, opposite sides are symmetrical in the number and position of the tubercles, and they seem to correspond to the macrospores contained within.

The substance of the sporocarps is carbonaceous, made up of minute, densely set, hexagonal cells, which, on the surface, appear as hexagonal pittings and in section as transverse vertical bars. The rock shows as many empty spore cases as filled, and dehiscence seems to have taken place, along a line which would compare to the "hinge" of a Beyrichia. The sporocarps (in section) contain usually two macrospores, sometimes three, and rarely four or more. Dr. Dawson has not noted the cellular structure in his characterization of this species, but has mentioned it as a feature of his species, Sp. (*Protosalvinia*) *Braziliensis*.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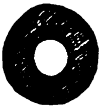
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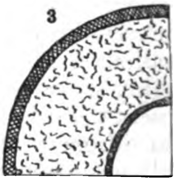
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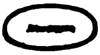
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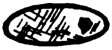
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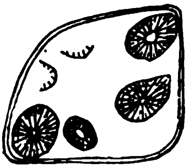
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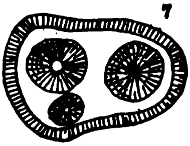
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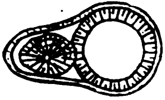
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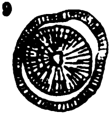
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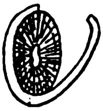
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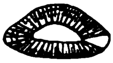
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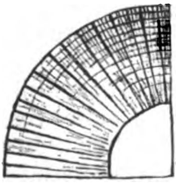
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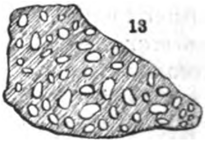
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Macrospores.—Usually free and so abundant as to make up the principal portion of the rock. In form spherical or ovoid, in size varying from one-fourth to one-half a millimeter in diameter. The surface is slightly papillose, wall thick and made up of radiating vertical fibers. These are sometimes seen to extend to the center (probably where the section does not pass the axis of the spore), but usually there is a vacant space about the center filled with crystalline calcite. This structure suggests that of the bodies known as *Aetheotesta* Brongniart. The radiating fibres are equally marked in both. My specimens lack, however, the granular nucleus of *Aetheotesta* and are very much smaller. In a few individuals I have noticed what appears to be a tubular opening through the wall of the spore into the interior cavity.

Microspores.—Less abundant than the macrospores are minute bodies associated with them and measuring from one-eighth to one-twentieth millimeter in diameter. These are round or irregularly oval in section, enveloped by a carbonaceous coat, but showing no structure. I have found no cases containing them, though it may be that some of the empty cases to be found originally enclosed them. These microspores do not, however, seem to be mixed indefinitely with the macrospores, but are generally in little clusters or masses by themselves.

These bodies are known as yet only from bowlders of Marcellus age, which are found in the township of Hopewell, N. Y. Notwithstanding the great difference in the size of these sporocarps and those of *Protasalvinia bilobata* the close agreement in more essential features will justify our regarding these as the North American representatives of the Brazilian type.

EXPLANATION OF FIGURES.

1. *Sporangites Huronensis* Dawson.—Preserving a thin carbonaceous outer wall and filled with calcite. Enlarged 10 diameters. From the Marcellus shales, Canandaigua, N. Y.

2. *Sporangites Huronensis?* Dawson.—Showing the dense wall with thicker exterior and interior layers. Interior filled with calcite. Enlarged 20 diameters. From the Corniferous Limestone, Mud Creek, Ontario county.

3. Section of the same enlarged to show the structure.

4. A somewhat flattened individual of the same, preserving only the dense exterior layer, and a carbonaceous mass at the center. This is the usual condition of preservation when a portion of the wall has been removed. Enlarged 20 diameters.

5. An individual of the same, showing the nucleus-like crystallization of calcite in what may have been the original interior cavity. Enlarged 20 diameters.

6. *Sporangites (Protosalvinia) bilobata* Dawson.—A sporocarp containing four macrospores and showing traces of two more. The structure of the sporocarp is not well preserved. Enlarged 20 diameters. From the calcareous layers of the Marcellus epoch, in the town of Hopewell, Ontario county.

7. A sporocarp of the same, showing its structure and containing three macrospores. Enlarged 20 diameters.

8. The same, with two macrospores. Enlarged 20 diameters.

9. The same, with but one macrospore. Such forms as this may be cross-sections of sporocarps containing more than a single spore. Enlarged 20 diameters.

10. A similar section, showing a dehiscent sporocarp. Enlarged 20 diameters.

11. A macrospore somewhat compressed and showing an apparent opening to the interior cavity. Enlarged 20 diameters.

12. A section of a macrospore enlarged to show the structure.

13. Microspores of this species. Enlarged 20 diameters.

ART. XL.—*Denudation of the two Americas;*[*] by T. MELLARD READE, C.E., F.G.S.

INTRODUCTION.

WHEN in 1876 I had the honor to deliver a Presidential address to this Society I chose as its subject matter "Geological Time," I then had the pleasure to lay before you some calculations relating to "Chemical Denudation" which at the time possessed some little novelty. Since the information was published, it has to a certain extent been incorporated with geological literature. The subject was, however, far from being exhausted, nor is it likely to be so for many years yet to come.

In the meantime, having accumulated additional facts, it will be part of the object of this address to arrange and analyze them, so as to check the original generalizations and further to illustrate the value in geological speculation of an accurate knowledge of the relative magnitude of the various objects and things dealt with.

My former calculations dealt almost exclusively with the amount of matter annually removed in river water from the surface of England and Wales, and from some of the river basins of Europe. I now propose laying before you calculations of a similar nature relating to some of the larger rivers of the two Americas. This done we shall be able to take a wider survey of the subject, and to ascertain how far the provisional generalizations to which previous investigations led are confirmed or otherwise by the greater experience since gained.

THE MISSISSIPPI.

First then we will see what the Father of Waters, the Mississippi, tells us. I may observe that for a long while I found great difficulty in obtaining answers to my various questionings. Years elapsed and letters innumerable were written before I could alight upon any analyses of the waters of the Mississippi, reliable or otherwise. At last through the kindness of Prof. J. W. Spencer, of the State University of Missouri, I was supplied with the following analysis:

Analysis of Mississippi water near Carrolton, a few miles above New Orleans:[†]

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[*] Substance of Presidential Address to the Liverpool Geological Society, Session 1884-5. Communicated by the author.

[†] Avequin, Journ. Pharm. [3], xxxvii, p. 258, 1857.

IN A GALLON (56,000 GRAINS).

	Grains.
Potash sulphate, " chloride, Calcium chloride,	3·154
Silica,	2·455
Alumina,	1·753
Calcium carbonate, Magnesium "	7·307
Organic matter,	0·818
Total solid residue,	15·487

According to this analysis the proportion of total solids in solution is by weight $\frac{1}{3615}$. If we take the mean annual discharge of the Mississippi at 541,666,666,666 tons* in round figures, there are 150 million tons of solids in solution per annum poured into the Gulf of Mexico by the Mississippi, a truly remarkable quantity, which if reduced to rock at 15 feet to the ton is represented in round numbers by 80 square miles, 1 foot thick. According to Messrs. Humphreys and Abbot the proportion of sedimentary matter to the water by weight is $\frac{1}{1500}$ and the total discharge of matters in suspension excluding the three outlet bayous is according to them 362,723,214 tons.

The amount of matters in solution vary within certain limits in river water according to the time the samples are taken. There are in some rivers, the Nile for instance, seasonal variations, and doubtless a river with many affluents, traversing strata of various degrees of solubility, must vary in the chemical composition of its waters according as the flood may come from one or the other tributary basin.

If we take the drainage area of the Mississippi proper at 1,214,000 square miles, the calculated amount of solids in solution, according to the analysis, will be 120 tons, removed from each square mile of surface per annum. From the surface of England and Wales I have shown that 143·5 tons per annum are removed in solution† and from the Danube basin 90 tons,‡ so that this is a mean and probably correct.

It has been estimated that the basin of the Mississippi is lowered at the rate of one foot in 6,000† years, but this rate has been calculated from the removal of sediment alone; § if we add to the matter removed mechanically that in solution it will raise the rate to one foot in 4,500 years.‖ What stronger evidence can we have of the importance of chemical action in geological investigation; an importance that has hitherto been strangely overlooked.

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* Report of Humphreys and Abbott, (1876), p. 146, 19,500,000,000,000 cubic feet at 36 feet to the ton.

† Geikie, Text book of Geology, p. 444. ‡ Chemical Denudation, p. 20.

§ According to the figures I have taken it would be one foot in 6,375 years.

‖ This is estimated as follows: Drainage area 1,244,000 square miles, annual sedimentary discharge from the same area 362,723,214 tons, solids in solution 150,000,000 tons, the average rock estimated at 15 feet to the ton. Strictly speaking, to this should be added 750,000,000 cubic feet of matter, estimated to be pushed along the bottom and the discharge from the bayous. For simplicity's sake I omit these elements.

Not less surprising considering the apparent insolubility of silica by ordinary agencies* is the fact that in round numbers from 23,000,000 to 24,000,000 tons of silica are poured into the sea annually by this river, while there are 70,000,000 tons of carbonate of lime and magnesia. There is also an exceptional quantity of alumina and a low percentage of sulphates in this water.

THE RIVER PLATE OR RIO DE LA PLATA.

The next river I shall deal with is the Rio de la Plata—the second greatest river of the South American continent. I am indebted to the very exhaustive series of observations and analyses of the waters of the river contained in the report to the Commission of running waters of the City of Buenos Ayres by Juan J. J. Kyle in 1872 and 1874,† for most of the information relating to this river.

I find that the mean of 14 analyses of water taken at different times (April, May and June) in the neighborhood of and above the City of Buenos Ayres gives a proportion of $\frac{1}{6445}$ of solids in solution, which, taking the dry weather flow of the La Plata at 670,000 cubic feet per second‡ (Bateman), will equal 2·8886 tons per second or 91,000,000 tons per annum in round figures.

The dry weather flow of the La Plata equals the *mean* annual flow of the Mississippi. The mean annual flow of the La Plata is not known but it must be greatly in excess of the dry weather flow and sufficient to bring up the total amount of dissolved matter to above that of the Mississippi though it appears from the analysis to have a less percentage of mineral matters in its waters than has the Mississippi. It appears from the report of 1874 that in two analyses of the La Plata water in September 15th and 18th, the matter in solution reached a proportion of $\frac{1}{3125}$. According to an analysis of the waters of the Paraná supplied me by Dr. Frankland§ they contained a proportion of only $\frac{1}{9926}$ of solids in solution. Mr. Juan Kyle states that there is very little difference between the waters of the La Plata taken at 850 m. from the shore and the waters of the Paraná de los Palmas. As the Paraná supplied, according to careful measurement by Mr. Bateman, 520,000 cubic feet of water to the La Plata, while the Uruguay was estimated at only 150,000 cubic feet at the same time, it follows that the chemical constituents of the water of the La Plata must vary considerably at different times and seasons. Probably the analysis on which I have made my calculations will represent a fair annual mean of the solids in solution.

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* Mr. M. E. Wadsworth has shown that ordinary atmospheric agencies produce a greater effect upon rocks of a siliceous character than is generally believed. See this Journal, Dec. 1884, p. 466.

† I must here express my thanks to Mr. J. E. Hawkes for his valuable assistance in translating the pamphlet for me.

‡ See Chemical Denudation, p. 55.

§ See Chemical Denudation, p. 23. 10·08 parts per 100,000.

The estimated drainage area of these two rivers is 1,250,000 square miles, so that were the mean annual discharge known it would probably turn out that the greater discharge of the La Plata would more than compensate for the smaller per centage of dissolved matters in its waters and bring the chemical denudation per square mile of river basin up to or beyond that of the Mississippi.

The observations of Mr. Bateman were taken in the month of December, 1870, when the river was at its lowest state. "A continuous drought of six or seven months having diminished the ordinary sources of supply and the periodical rise from the Andes not having commenced." It is difficult, nay, impossible, to predict the mean delivery from the dry weather flow, but the mean flow of the Rhine is given by Beardmore as over twice, the Rhone at Avignon nearly three times, and the Nile at Cairo over seven times the ordinary summer flow.

The waters of the La Plata are distinguished by the fineness of the matter held in suspension; this consists, according to Mr. Kyle, principally of clay. This clay continues a long time in suspension even after filtering. It will pass through the pores of the best filtering papers, the water preserving its turbidity even after months of repose. This is a feature according to Mr. Kyle which is common to all waters that are weakly alkaline. Several chemicals added to the water will, however, precipitate the solid matter by making the muddy particles coagulate into larger compound particles. Chloride of calcium in the proportion of 1 to 5,000 parts will act in this manner. The analyses given by Mr. Kyle are of the water after 48 hours subsidence, so that the unprecipitated matter is included in the solids in solution. The matters in suspension, as is the case with other rivers, vary much according to the state of the river and the water is more impure near the shore than at 850 m. distant.

It is pretty well known that an admixture of seawater with turbid fresh water tends to hasten the precipitation of the solid matters* but it is very probable, as will be seen before I conclude, that the extremely divided solid matter will be carried far and wide by oceanic currents before it can settle to the bottom.

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* See "precipitation of Clay in fresh and salt water," by D. Robertson, Trans. Glasgow Geol. Soc., vol. iv, Part III, page 257.

The annual amounts of solids in suspension in the La Plata waters has never to my knowledge been determined or even approximately estimated.

THE ST. LAWRENCE.

The next river on the American Continent of which we have any knowledge worth speaking of is the St. Lawrence. The elements for a calculation such as I wish to make are however unfortunately rather vague. Even the area of its basin is stated differently by different authors. According to Guyot* its basin, including, I presume, the area of its immense lakes, is two-fifths that of the Mississippi, while it is said to pour into the sea more than twice its volume. This must, however, be an error, for it would give 40 inches of rain run off the area per annum, whereas, according to the Rainfall Map of the World, prepared by Loomis (this Journal, vol. xxv, p. 88, January, 1883) the whole basin lies in the area of rainfall of from 25 to 50 inches. If we were to take it at 20 inches run off the ground per annum, or half the stated delivery, after deducting the area of the great lakes, the chemical denudation would still be enormously great. The only analysis I have met with gives the proportion of solids in solution at $\frac{1}{6230}$† so that the denudation would amount to, at that rate, over 200 tons per square mile per annum. The one thing probable, however, is, that the matter removed in solution is more per square mile than in the Mississippi basin. The matter removed to the sea in suspension must be comparatively small from the clearness of the water due to its passing through the great lakes.

THE AMAZONS.

The River Amazons is compared by Agassiz in its main features to the Mississippi, inasmuch as it lies in a Cretaceous basin.‡ I think, however, the analogy is a fanciful one. The valley of the Amazons is distinguished from other river valleys by its immense extent, the drainage basin being estimated by Humboldt at over 3 million square miles. The basin appears to have existed much in its present form before it became partially filled with the remarkable deposits of red sandstones and clays covering an immense area which the river is now engaged in rapidly removing to the sea. The upland portions of the basin are largely composed of the granitic and crystalline rocks which are so prominent a feature in the Brazils. The sandstones and clays that have so large a development over the bottom of the basin appear to be Post-tertiary and laid down by the river itself in more ancient times. There are, however,

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* Physical Geography. † 16·05 per 100,000 parts, Jahresbericht der Chemie.
‡ Geological sketches—Physical History of the Valley of the Amazons, p. 171.

Tertiary rocks in a part of the basin* possessing an estuarine character in addition to Cretaceous rocks, while on the flanks of the Andes draining into the river are found both cretaceous and Carboniferous rocks. The larger area of the basin appears, however, to be occupied by crystalline rocks and the Post-tertiary sandstones and clays; but a very large part of the basin seems never to have been geologically explored. The basin of the Amazons has also the peculiarity of being situated both to the north and south of the equator and in an area of very heavy rainfall. The chart of mean annual rainfall by Loomis before referred to puts it at from 50 to 75 inches for about ⅔ of its area, the remainder near the Andes being over 75 inches. The volume of water discharged by the river has been estimated at from 2,700,000 to 3,510,000 cubic feet per second. Taking the mean, this would give about 15 inches run off the ground, or 0·25 of the total rainfall if we take it at 60 inches, about the proportion that flows off the Mississippi basin. The mean rainfall of the Mississippi basin is estimated by Messrs. Humphreys and Abbot at 30·4 inches. Probably 60 inches, would represent the mean rainfall of the Amazons basin. For the purposes of this calculation I take the mean discharge at 3,105,000 cubic feet per second, or 86,250 tons=2,719,980,000,000 tons per annum.†

Through the good offices of Mr. E. Edmondson of Messrs. Gunston & Co., of this city, I have obtained a sample of the water of the Amazons, taken in mid-stream between the Narrows and Santarem in June of this year. This sample I submitted to Dr. Pery I. Frankland for analysis with the following result:

	Parts in 100,000.
Silica	0·98
Iron and alumina	0·38
Carbonate of lime	2·75
Carbonate of magnesia	0·22
Sulphate of magnesia,	0·37
Chlorate of potassium	0·23
Chloride of sodium	0·15
Sulphate of soda	0·13
Organic matter	0·71
Total solids in solution	5·92

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* See "On the Tertiary deposits on the Solimoes and Javury Rivers in Brazil by C. Barrington Brown, Quart. Journ. Geol. Soc., 1879," also "Ancient River Deposits of the Amazons," ibid.

† Bates, Naturalist on the Amazons, vol. i, page 237, says: Von Martius estimates the volume of water passing through the straits of Obydos at 499,584 cubic feet per second. He arrives at this result by taking the depth in the middle at 60 fathoms and at the sides 20 fathoms, the width is given at 1738 yards. Suspecting some error—as the volume of the La Plata in dry weather exceeds this estimated volume of the Amazons—I have re-calculated the delivery from these elements and find that it cannot be less than 3,000,000 cubic feet per second, but may be more according to the form of the bottom. Our gratitude is due to those who give us the means of checking their results.

This gives a proportion of total solids in solution of $\frac{1}{16,890}$ or 5·1 tons per second.

The total delivery of matters in solution will amount, according to these data, to 160,833,600 tons per annum, or, if we estimate the basin at 3,000,000 square miles, to 60 tons per square mile per annum.

It will be observed that the total amount delivered to the sea of solids in solution is not much greater than that we arrived at for the Mississippi. This is a fact worth knowing and due doubtless to the preponderance of gneissic rocks and sandstones and clays of an insoluble character. It is also worth noting that the proportion of silica to the total matter in solution corresponds very closely with that of the Mississippi, amounting to 26,624,481 tons per annum. It is also evident that the rocks and Pampean deposits* occupying the basin of the La Plata are also of a more calcareous and soluble character than the Amazonian Rocks. Not less interesting is it that the carbonate of lime. roughly speaking, is one half of the whole of the solids in solution.†

It follows from these data that the matter removed in suspension must bear an excessive proportion to those in solution as compared to other rivers. The deposits forming the banks of the river are of a loose and friable nature on which the river makes great inroads. The proportion of matters in suspension has never to my knowledge been estimated. Bates, comparing the Pará and the main Amazons, says, "In the former the flow of the tide always creates a strong current upwards, while in the Amazons the turbid flow of the mighty stream over-powers all tides, and produces a constant downward current. The color of the water is different, that of the Pará being of a dingy orange-brown, while that of the Amazons has an ochreous or yellowish clay tint," also "Indeed the fresh water tinges the sea along the shores of Guiana to a distance of nearly 200 miles from the mouth of the river."‡

INFERENCES AND GENERALIZATIONS.

In my former address I said, "Taking into consideration what we know of the geology of the world, I think we have sufficient grounds for a provisional assumption that about 100 tons of rocky matter are dissolved by rain per English square mile per annum."§ This at the time was considered a very bold statement, but from the data I have laid before you respecting the American continents I venture to think it will be now considered as applied to the whole world a very fair approximation.

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* See Geological Observations, Darwin, Second Edition, pp. 313 to 369.

† See Chemical Denudation, p. 24. ‡ Naturalist on the Amazons, vol. i, p. 5.

§ Chemical Denudation, p. 24.

Let us pause to consider the meaning of all these figures, for unless they have a meaning which the mind and imagination can seize upon, the wearisome labors of collecting the data and making the computations were well nigh wasted.

First, as regards the Mississippi, of which we possess the most reliable particulars.—I have shown that the estimate of the rate of denudation of its basin must be increased in round figures from $\frac{1}{6000}$ to $\frac{1}{4500}$ of a foot per annum* in consequence of the solid matter which is removed in solution. Is it not a striking instance of the little importance attached to chemical denudation as a geological agent, when the matter removed in solution does not enter as an element into the calculations of such an observant reasoner as a Geikie or a Croll. Thus we arrive at the first and not unimportant result which I promised from quantitative examination. Now mark, it is not that geologists were unaware of the effect of chemical action on the rocks. Take up any text-book or manual and you will find a chapter devoted to it and the whole process correctly explained, nevertheless the quantity of matter removed was not realized and never could have been except through laborious calculations. That being done it is easy to see how these great results occur. Examine the hardest rock and you will find it weathered, you will find it coated over with a crust, of a thickness varying with the time its surface has been exposed. This crust is composed of the constituents of the rock that remain after part have been removed by chemical action.† Examine the waste talus from some of the old quarries at Penmaenmawr and you will see that atmospheric agents have in the space of 80 years perceptibly affected a felstone rock that seems at first sight absolutely indestructible.‡ How much more then must they affect rocks of a more friable and soluble nature. I have shown that $\frac{1}{12978}$ of a foot per annum is removed from the surface of England and Wales in a soluble form every year,§ say $\frac{1}{1081}$ of an inch, so that in 30 years it would amount to $\frac{1}{36}$ of an inch.

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* This calculation as before explained takes no account of matters pushed along the bottom, they have not been determined with much accuracy and it is probable as Mr. A. Tylor has suggested there is more than has been estimated. This would further reduce the time.

† It is usual to refer this action entirely to the carbonic acid present in the rain water, but Mr. Alexis A. Julien has brought forward a great body of facts to prove that the solvents of the rocks are largely organic acids existing in decaying vegetable matter. "On the geological action of the Humous Acids." Proc. of the American Assoc. for the Advancement of Science, Saratoga meeting, 1879.

‡ This stone is largely used for making "setts" for street paving, sold under the name of "Welsh granite setts," and found to be the most lasting material for the purpose.

§ Chemical Denudation.

This is the mean denudation, but I have also shown that the denudation is very much equalized by the fact of the harder rocks usually occurring in areas of great rainfall.*

It is therefore not unlikely that, if we were to institute accurate experiments over a sufficiently long time, it would turn out that the calculation of the amount of matter removed in solution could be verified by direct tests, and that even these hard rocks would be found to waste at something near the indicated rate. It would appear from the examples of the Mississippi, the Nile and Danube that the matter brought down in solution and suspension is as 1 to 3.

These examples are of rivers where there have been the most accurate and fullest data to judge by. Whether the proportion would be borne out in other river basins we have no very good means of judging; but it would appear that in large rivers the nature of the rocks is so varied, the areas being so extensive, that the relation of the materials in solution to those in suspension have a tendency to keep very constant. It will be seen from a consideration of these facts that matters chemically dissolved in the water must play a much more important *role* in the reconstruction of the earth than was formerly suspected.†

What becomes of all these mineral matters ceaselessly flowing into the sea? It has been shown by Mr. Buchanan‡ that the proportions of mineral matters to each other in sea water is nearly constant everywhere, although there is a variation in different seas in the proportion of total mineral matter in solution to the water it is dissolved in. Nature has achieved a balance of supply and demand. It is also well known that the coarser matters in suspension, unless brought under the influence of a strong current, settle near the mouths of the rivers and then spread themselves by help of tides and winds along the coast and there mingle with the detritus the sea wears away from the coast. The finer particles distribute themselves over a larger area and probably the very finest over the whole sea bottom. In every ocean dredging there is a greater or less amount of argillaceous matter, whether it be in the ooze or the red clay, which I suggest is more likely to be the "dust of continents," than to arise from the disintegration of volcanic matter, such as pumice, but it is no doubt largely mingled with such volcanic matters as Mr. Murray clearly shows. It seems to me rather a far-fetched notion that the winds should contribute dust to the deepest ocean, but that the waters should make no mechanical contribution to the deposit. The bulk of the ocean water is so great as compared to the probable amount of matter in a state of the finest comminution that can get into it, that it might not even be possible to detect its presence in a sample of ocean water. At the same time it might contain quite sufficient to account for much of the argillaceous matter found in the deep ocean soundings. I have shown that the matters in solution in rain waters are, roughly speaking, one quarter of the whole matter in the water in solution and suspension. The finest particles, sufficiently fine to be carried away by oceanic surface currents, such as the Gulf Stream, are probably not in bulk half as great as the matter in solution. If we take as an example the estimate I have given of the chemical denudation of England and Wales it amounts, as I have already shown, to $\frac{1}{36}$ of an inch in 30 years. This would give, supposing the impalpable mud to be worn off at half that rate, 60 years for the denudation of $\frac{1}{36}$ of an inch. The area of the sea to land is roughly as 3 to 1, therefore at this rate it would take 180 years for $\frac{1}{36}$ of an inch of mud converted into rock to accumulate if distributed evenly over the ocean floor. When we consider the average depth of the ocean is over two miles, $\frac{1}{36}$ of an inch distributed through it would amount to no more than about one five-millionth part, and this, be it remembered, has 180 years to accumulate and settle, so that if we give each particle of these fine matters in suspension 10 years to settle to the bottom there would never be in the ocean water at one time more than one ninety-millionth part of matters in suspension, an amount so small as to be practically imperceptible. The probability that such an infinitesimal amount of matter in suspension may be present is still more evident when we find that fine sand floats on the surface of the sea for considerable distances, for Prof. Verrill says that in the course of the Gulf Stream they always take with their towing nets more or less fine siliceous sand* (this Journ., 1882, xxiv, p. 449).

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* Chemical Denudation.

† It is singular that Hutton in his theory of the earth estimates at a gross computation "that the fourth of the solid land is composed of matter which had formed the calcareous tests of animals"

‡ Challenger Reports.

I think it is fairly evident from the foregoing calculations that there may be accumulations going on in the great oceans which we can no more see than we can the matters in solution.* It is only because the mineral matters get concentrated in the sea water that they are forced upon our notice. They slowly concentrate until a balance is attained and they are removed from the sea water at the same rate that they are poured into it.

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* Prof. A. E. Verrill also says that, in the Gulf Stream slope examined by us, the bottom in 70 to 300 fathoms, 60 to 120 miles from the shore, is composed mainly of very fine sand, largely quartz, with grains of feldspar, mica, magnetite, &c.; with it there is always a considerable percentage of shells of foraminifera and other calcareous organisms, and also spherical, rod-like and stellate sand-covered rhizopods often in large quantities. In the deeper localities there is usually more or less genuine mud or clay, but this is often almost entirely absent even in 300 to 500 fathoms. The sand however is often so fine as to resemble mud and is frequently so reported when the preliminary soundings are made and recorded." "The prevalence of fine sand along the Gulf Stream slopes in this region and the remarkable absence of actual mud or clay deposits indicate that there is here at the bottom sufficient current to prevent for the most part the deposition of fine argillaceous sediments over the upper portion of the slope in 65 to 150 fathoms. Such materials are probably carried along till they eventually sink into the greater depths nearer the base of the slope, or beyond in the ocean basin itself, where the currents are less active." (This Journal, vol. xxiv, pp. 448–9, 1882.)

Art. XLI.—*On Arctic Interglacial Periods;* by James Croll, LL.D., F.R.S.†

Polar *Interglacial Periods more marked than the Glacial.*—In a former paper,‡ and also in 'Climate and Time' (chap. xvi), it was pointed out that in temperate regions the cold periods of the Glacial epoch would be far more marked than the warm interglacial periods. In temperate regions the condition of things which prevailed during the cold periods would differ far more widely from that which now prevails than would the condition of things during the warm periods. But as regards the polar regions the reverse would be the case; there the warm interglacial periods would be more marked than the cold periods. The condition of things prevailing in these regions during the warm periods would be in strongest contrast to what now obtains; but this would not hold true in reference to the cold periods, during which matters would be pretty much the same as at present, only somewhat more severe. In short, the glacial state is the normal condition of the polar regions, the interglacial, the abnormal. At present Greenland and other parts of the Arctic regions are almost wholly covered with snow and ice, and, consequently, nearly destitute of vegetable life. In fact, as regards organic life in those regions, matters during the Glacial epoch would not probably be much worse than they are at the present day. Greenland and the Antarctic continent are to-day almost as destitute of plant-life as they could possibly be. Although, in opposition to what is found to be true in reference to the temperate regions, the polar interglacial periods were more marked than the glacial, it does not follow that on this account the relics of the interglacial periods which remain ought to be more abundant in polar than in temperate regions. On the contrary, the reverse ought to be the case. In the polar regions, undoubtedly, there is least likelihood of finding traces of interglacial periods; for there, of all other places, the destruction of such traces would be most complete. The more severe the glaciation following a warm period, the more complete would be the removal of the remains belonging to the period. If in such places as Scotland and Scandinavia so little is left of the wreck of interglacial periods, it need be a matter of no surprise that in Arctic regions scarcely a relic of those periods remains. The comparative absence in polar regions of organic remains belonging to a mild interglacial period cannot therefore be adduced as evidence against the probable existence of such a period. Who would expect to find such remains in ice-covered regions like Greenland and Spitzbergen? Although not a trace is now to be found, it is nevertheless quite possible that during interglacial periods those regions may have enjoyed a comparatively mild and equable climate.

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* Mr. Thomas Higgin, F.L.S., of Anderton Salt Works, Northwich, prepares his finest quality of salt by precipitating the slight proportion of muddy impurities which the cold brine holds in suspension by heating it in large vats. At my suggestion he carried out a series of experiments to determine the proportion of mud so removed. He found that it amounted to 57 lbs per 1,556 tons of brine $=\frac{1}{61148}$. Looking at the brine, purified and unpurified together in clean bottles, the difference between them is so faint as to be hardly distinguishable. It of course affects the color of the manufactured salt to a much greater extent both by the higher proportion the impurities bear to the salt and the whiteness of the salt.

† Phil. Mag., Jan., 1885. Communicated by the author.

‡ Phil. Mag., May, 1884, p. 375; this Journal, June, 1884.

Evidence from the Mammoth in Siberia.—This comparative absence of the remains of a warmer condition of climate in Arctic regions during Pleistocene times holds true, however, only in regard to those parts, like Greenland, which have undergone severe glaciation. When we examine Siberia and other places which appear to have escaped the destructive power of the ice, we find, from a class of facts, the physical importance of which appears to have been greatly overlooked, abundant proofs of a mild and equable condition of climate. I refer to facts connected with the climatic condition under which the Siberian Mammoth and his congeners lived. The simple fact that the Mammoth lived in Northern Siberia proves that at the time the climate of that region must have been far different from what it is at the present day.

The opinion was long held, and is still held by some, that the Mammoth did not live in Northern Siberia, where his remains are found, but in more southern latitudes and that these remains were carried down by rivers. It was considered incredible that an animal allied to the Elephant, which now lives only in tropical regions, should have existed under a climate so rigorous as that of Siberia. The opinion that the remains were floated down the Siberian rivers is now, however, abandoned by Russian naturalists and other observers who have carefully examined the country.

I shall here give a brief statement of the facts and arguments which have been adduced in support of the theory that the Mammoth lived and died where its remains were found. For these facts I am mainly indebted to the admirable papers by Mr. Howorth on the Mammoth in Siberia, which appeared in the Geological Magazine for 1880.

Had the remains of the Mammoth been carried down from the far south by the Siberian rivers, they would have been found mainly, if not exclusively, on the banks of the long rivers, such as the Obi, Yenissei and the Lena, and in the deltas formed at their mouths. But such is not the case "These are," says Mr. Howorth, "found even more abundantly on the banks of the very short rivers east of the Lena. They are found not only on the deltas of these rivers, but far away to the north, in the islands of New Siberia, beyond the reach of the currents of the small rivers, whose mouths are opposite those islands." But a more convincing proof is that "they are found not only in North Central Siberia, where the main arteries of the country flow, but in great numbers east of the river Lena, in the vast peninsula of the Chukchi, in the country of the Yukagirs, and in Kamtskatka, where there are no rivers down which they could have floated from more temperate regions." Besides, it is not merely in the deltas and banks of rivers that the remains are found, but in nearly all parts of the open tundra; and Wrangell says* that the best, as well as the greatest number of remains are found at a certain depth below the surface in clay-hills, and more in those of some elevation than along the low coast or in the flat tundra.

Had the Mammoth lived in the south we should, as Mr. Howorth further remarks, have found its remains most abundant in the south, whereas the farther north we go the remains become more abundant, and in the islands of the Liachof archipelago, in about latitude 74°, the greatest quantities have been discovered. Again, according to Hedenstrom, the bones and tusks found in the north are not so large and heavy as those in the south; a fact which still further confirms the opinion that the Mammoth lived where his remains are found, inasmuch as the greater severity of the climate in northern parts would certainly hinder the growth and full development of the animal.

Northern Siberia much warmer during the Mammoth Epoch than now.—It is true that the Mammoth and the *Rhinoceros tichorhinus* were furnished with a woolly covering which would protect them from cold; but it is nevertheless highly improbable that they could have endured a climate so severe as that of Northern Siberia at the present day, where the ground is covered with snow for nine months in the year and the temperature is seldom much above zero Fahr. And even if they could have endured the cold, they would have starved for want of food. Some parts of Siberia are no doubt fertile, as, for example, the valley of the Yenisei, described by Nordenskjöld;* but there is little doubt, as Mr. Howorth remarks, that the larger portion of Northern Siberia, where the Mammoth and the Rhinoceros lived, is now a naked tundra covered with moss, on which no tree will grow. On such ground it is physically impossible that the Mammoth and Rhinoceros could exist, for they cannot graze close to ground like oxen. They live on long grass and on the foliage and small branches of trees.

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* Polar Sea Expedition, English translation, p. 275.

Evidence from Wood.—The fact that the Mammoth was most abundant beyond the present northern limit of wood is pretty good evidence that the climatic condition of Northern Siberia must have been milder than now. Wood must have extended, in the days of the Mammoth, far beyond its present limit, probably as far north as New Siberia: facts of observation support this conclusion.

The wood found in Northern Siberia consists of two classes—the one is the result of drift, the other grew on the spot. The natives call the former "Noashina," and the latter "Adamshina;" and the division is supported by Göppert, "who separates the trunks of timber found in Northern Siberia into a northern series, with narrow rings of annual growth, and a southern, with wider ones. The latter doubtless floated down the rivers, as great quantities do still; while the former probably grew here with the Mammoth."

In the middle of October, 1810, Hedenstrom went across the tundra direct to Ustiansk. "On this occasion," he says, "I observed a remarkable natural phenomenon on the Chastach Lake. This lake is 14 versts long and 6 broad, and every autumn throws up a quantity of bituminous fragments of wood, with which its shores in many places are covered to the depth of more than 2 feet. Among these are pieces of a hard transparent resinous substance, burning like amber, though without its agreeable perfume. It is probably the hardened resin of the larch tree. The Chastach Lake is situated 115 versts from the sea and 80 versts from the nearest forest."†

On the same journey Hedenstrom noticed "on the tundra, equally remote from the present line of forest, among the steep sandy banks of the lakes and rivers, large birch trees, complete, with bark, branches and root. At the first glance they appeared to have been well preserved by the earth; but, on digging them up, they are found to be in a thorough state of decay. On being lighted they glow, but never emit a flame:

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* 'Nature,' Dec. 2, 1875.

† Wrangell, p. 491.

nevertheless the inhabitants of the neighborhood use them as fuel, and designate these subterranean trees as *Adamoushtshina*, or of Adam's time. The first living birch tree is not found nearer than three degrees to the south, and then only in the form of a shrub."*

On the hills in the interior of the Island of Koteloni "Sannikow found the skulls and bones of horses, buffaloes, oxen and sheep in such abundance that these animals must formerly have lived there in large herds. At present, however, the icy wilderness produces nothing that could afford them nourishment, nor would they be able to endure the climate. Sannikow concludes that a milder climate must formerly have prevailed here, and that these animals may therefore have been contemporary with the Mammoth, whose remains are found in every part of the island."†

"Herr von Ruprecht reported to Brandt that, at the mouth of the Indiga, in 67° 39′ N. lat., on a small peninsula called Chernoi Noss, where at present only very small birch bushes grow, he found rotten birch trunks still standing upright, of the thickness of a man's leg and the height of a man. In going up the river he met with no traces of wood until he reached the port of Indiga. Here he noticed the first light-fir woods growing among still standing but dead trunks. And higher up the river still, the living woods fairly began."‡

Schmidt says that, "where the lakes on the tundra have grown small and shallow, we find on and near their banks a layer of turf, under which, in many places, *are remains of trees in good condition, which support the other proofs that the northern limit of trees has retrogressed, and that the climate here has grown colder*. I found, on the way from Dudino to the Ural Mountains, in a place where larches now only grow in sheltered river-valleys, in turf on the top of the tundra, prostrate larch trees still bearing cones."§

Schmidt also states that he was informed that at Dudino, just at the limit of the woods, there had been found in a miserable larch wood the lower part of a stem sticking in the ground, apparently rooted, which was three feet in diameter. He also states that, "eleven versts above Krestowkoje, in lat. 72°, he found, in a layer of soil covered with clay on the upper edge of the banks of the Yenissei, well-preserved stems like those of the birch, with their bark intact, and sometimes with their roots attached, and three to four inches in diameter. Professor Merklin recognizes them as those of the *Alnaster fruticosus*, which still grows as *a bush* on the islands of the Yenissei, in lat. 70½° N."

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* Wrangell, p. 492. † Wrangell, p. 496.

‡ Bull. Soc. Nat. Moscow; quoted by Howorth.

§ Schmidt, as quoted by Howorth.

Evidence from Shells.—In the freshwater deposits in which the bones of the Mammoth are found, there are fresh-water and land-shells, which indicate a warmer condition of climate. I quote the following from Mr. Howorth's memoir:—

"Schmidt found *Helix Schrencki* in fresh-water deposits on the tundra below Dudino and beyond the present range of trees. Lopatim found recent shells of it, with well-preserved colors, 9° farther south, in lat. 68° and 69°, within the present range of trees, at the mouth of the Awamka. The most northern limit hitherto known for this shell was in lat. 60° N., where they were found by Maak in gold-washings on the Pit."

"In the freshwater clay of the tundra by Tolstoi Noss, Schmidt found *Planorbis albus*, *Valvata cristata*, and *Limnœa auricularia* in a sub-fossil state; *Cyclas calyculata* and *Valvata piscinalis* he found thrown up on the banks of the Yenissei, and on a rotten drifted trunk, *Limax agrestis; Anodonta anatina* he also found on the banks of the Yenissei as far as Tolstoi Noss, but no farther. *Pisidium fontinale* still lives in the pools on the tundra; as does *Succinea putris* on the branches of the Alnaster on the Brijochof Islands."

Mr. Belt mentions* that the *Cyrena fluminalis* is found in Siberia in the same deposits which contain the remains of the Mammoth and the *Rhinoceros tichorhinus.*

"The evidence, then," says Mr. Howorth, "of the *débris* of vegetation, and of the fresh-water and land-shells found with the Mammoth-remains, amply confirms the *à priori* conclusion that the climate of Northern Siberia was at the epoch of the Mammoth much more temperate than now. It seems that the botanical facies of the district was not unlike that of Southern Siberia, that the larch, the willow, and the Alnaster were probably the prevailing trees, that the limit of woods extended far to the north of its present range and doubtless as far as the Arctic Sea; that not only *the mean temperature was much higher, but it is probable that the winters were of a temperate and not of an Arctic type.*"—Geol. Mag., December, 1880.

The Mammoth Interglacial.—It need be a matter of no surprise that the climate of Northern Siberia during the time of the Mammoth was more mild and equable than now, if we only admit that the Mammoth was interglacial. That it was of interglacial age is a conclusion which, I think, has been well established by Prof. J. Geikie and others. Into the facts and arguments which have been advanced in support of this conclusion I need not here enter. The subject will, however, be found discussed at great length in Prof. Geikie's 'Prehistoric Europe' and in 'The Great Ice-Age' (second edition). Mr. R. A. Wallace considers that one of the last intercalated mild periods of the Glacial epoch seems to offer all the necessary conditions for the existence of the Mammoth in Siberia. That the Mammoth was interglacial will be further evident when we consider the climatic conditions of Europe at the time that it lived there. Before doing so, it may be as well to glance at what evidently were the main characteristics of the interglacial periods.

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* Quart. Journ. Geol. Soc., vol. xxx, p. 464.

Main Characteristics of Interglacial Climate.—They are as follows:

1. Interglacial conditions neither did nor could exist *simultaneously* on both hemispheres. They existed only on one hemisphere at a time, viz: on the hemisphere which had its winter solstice in perihelion.

2. During interglacial periods the climate was more *equable* than it is at present; that is to say, the difference between the summer and winter temperatures was much less than it is now. The summers may not have been warmer or even so warm as they are at present, but the temperature of the winters was much above what it is at the present day.

3. During the interglacial periods the quantity of equatorial heat conveyed by ocean-currents into temperate and polar regions was far in excess of what it is at present. On this account a greater *uniformity* of climate then prevailed: that is to say, the difference of climatic conditions between the subtropical and the temperate and polar regions was less marked than at present—the temperature not differing so much with latitude as it now does.

4. *Mildness*, or a comparative absence of high winds, characterized interglacial climate. This partial exemption from high winds resulted from the fact that the difference of temperature between the equator and the poles, the primary cause of the winds, was much less than at the present day.

5. Another character of interglacial climate was a *higher mean temperature* than now prevails. This, amongst other causes, resulted from the great amount of heat then transferred by ocean-currents from the glacial to the interglacial hemisphere.

6. During interglacial periods the climate was not only more equable, mild, and uniform than now, but it was also more *moist.* This was doubtless owing mainly to the fact of the presence then in temperate and polar regions of so large an amount of warm intertropical water. In short, it was the presence of so much warm water from intertropical regions which mainly gave to the climate of the interglacial periods its peculiar character.

All these characteristics of interglacial climate have been fully established by the facts of geology, but they are also, as we have seen, deducible *à priori* from physical principles. They follow as *necessary consequences* from those physical agencies which brought about the Glacial epoch.

Evidence from the Mammoth in Europe.—Skeletons and detached remains of the Mammoth have been found in nearly every country in Europe. Mr. Howorth in his memoir,* gives the details of the finding of these in various parts of Russia, Germany, Denmark, Sweden, Belgium, France, England, and other countries. It is shown that the conditions under which the Mammoth-remains have been found in Europe are almost identically the same as those under which they are found in Siberia, with the exception, of course, that in Europe no carcasses with their flesh intact have been met with.

Again, the deposit in which the Mammoth-remains are found in Europe is the same as that in which they occur in Siberia. The deposit is a freshwater one, consisting of marly clay and gravel, and containing plant-remains and land- and freshwater-shells. When these plants and shells are examined, they are found to indicate the same interglacial condition of climate as that which prevailed in Siberia during the time the Mammoth lived in that region.

In the case of land-plants it is, of course, only under exceptional circumstances, as Prof. J. Geikie remarks, that they can be found in a condition suitable for the botanist. Now and again, however, beds with well-preserved plants are met with, buried under lacustrine deposits. In a still better state of preservation are the plant-remains and shells which have been discovered in the masses of calcareous tufa which have been formed upon the borders of incrusting springs. An examination of the plant-remains found under these conditions shows that during the Pleistocene times, when the deposits in which the Mammoth bones are found were being formed, the climate was more equable and uniform than it is at the present day.

The fossiliferous remains yielded by the tufas have led to most important results as to the climatic condition of the Pleistocene period, into the details of which I need not here enter. These will be found at full length in Prof. J. Geikie's Prehistoric Europe, chap. iv.† It will suffice at present simply to refer to the general conclusions to which these researches have led, in so far as they bear on the climatic conditions prevailing at the time the Mammoth lived so abundantly in Europe.

In the tufa deposits of Tuscany have been found numbers of plant-remains of indigenous species, commingled with others which now no longer grow in Tuscany. Amongst the latter is the Canary laurel, which now flourishes so luxuriantly in the

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* Geol. Mag., May, 1881.

† See also Mr. Howorth's memoir, Geol. Mag., June, 1881.

Canary Islands, on the nothern slopes of the mountains, at an elevation of from 2,000 to 5,000 feet above the sea-level—a region, remarks Prof. J. Geikie, nearly always enveloped in steaming vapors, and exposed to heavy rains in winter. In that deposit is also found the common laurel, associated with the beech. This is not now the case, as the laurel requires more shade than it can find there at the present, while the beech has retreated to the northern flanks of the Apennines to obtain a cooler climate.

In the tufas of Provence are found groups the same as those which flourish there at present, but commingled with them are also the Canary laurel and other plants which are no longer natives of Provence. Saporta directs attention to the fact that species such as the Aleppo pine and the olive, demanding considerable summer-heat rather than a moist climate, are entirely wanting in the tufas.

Similar to those of Provence are the tufas of Montpellier. Saporta concludes that when all those species lived together the climate must necessarily have been *more equable and humid* than at present. In other words, the summers were not so dry and the winters were milder than they are now.

The deposit near Moret, in the valley of the Seine, is still more remarkable in showing the equable condition of climate which than prevailed. The assemblage of plants found there tells a tale, says Prof. J. Geikie, which there is no possibility of misreading. "Here," he says, "we have the clearest evidence of a genial, humid, and equable climate having formerly characterized Northern France. The presence of the laurel, and that variety of it which is most susceptible to cold, shows us that the winters must have been mild, for this plant flowers during that season, and repeated frosts, says Saporta, would prevent it reproducing its kind. It is a mild winter rather than a hot summer which the laurel demands, and the same may be said of the fig-tree. The olive, on the other hand, requires prolonged summer heat to enable it to perform its vital functions. Saporta describes the fig-tree of the La-Celle tufa as closely approximating, in the size and shape of its leaves and fruit, to that of the tufas in the south of France, and to those of Asia Minor, Kurdistan and Armenia. But if the winters in Northern France were formerly mild and genial, the summers were certainly more humid, and probably not so hot. This is proved by the presence of several plants in the tufa of La-Celle which cannot endure a hot arid climate, but abound in the shady woods of Northern France and Germany."

The plants found in the tufas of Canstadt are much similar to those of Moret. Mr. Howorth, in regard to the deposits of those places, says: "The coexistence of the species found there, remarks M. Saporta, proves very clearly that, notwithstanding the variations due to latitude, Europe, from the Mediterranean to its central districts, offered fewer contrasts, and was more uniform than it is now. A more equable climate, damp and clement, allowed the *Acer pseudo-platanus* and the fig to live associated together near Paris, as it allowed the reindeer and hyæna. The *Acer* grows with difficulty now where the *Ficus* grows wild, while the latter has to be protected in winter in the latitude of Paris."*

Equally conclusive is the testimony borne by the Mollusca of the tufas. In the tufas and marls of Moret, in the valley of the Seine, thirty-five species were discovered. The majority of these must have lived in damp and shady places, in the recesses of moist woods, and on the leaves of marsh-plants. The shells, M. Tournouër concludes, bespeak a condition of climate more uniform, damp, and equable than now prevails in that region, with a somewhat higher mean annual temperature. In the alluvial deposits of Canstadt, in Wurtemberg, a class of shells indicating a similar condition of climate has been discovered.

The evidence furnished by the animals found most abundantly with the Mammoth in Europe and Siberia, Mr. Howorth thinks, points to the same conclusion as that of the plants and mollusca.

The same mild and equable condition which allowed of the Mammoth living in Northern Siberia during Pleistocene times thus equally prevailed over the whole of Europe. We have seen that, according to the Physical theory, this condition of climate was in every respect precisely what it ought to have been on the supposition that it was interglacial. It was a condition mild, equable, uniform, humid, and of a higher mean annual temperature than we have at the present day. There is, however, direct and positive evidence that this condition of climate was interglacial; for the facts both of geology and of paleontology show that it was preceded and succeeded by a state of things of a wholly opposite character.

The Mammoth Glacial as well as Interglacial.—Although the Mammoth could have lived in Arctic Siberia only during an interglacial period, it does not follow that it must have perished during the succeeding glacial period. When the cold came on, and the vegetation on which it subsisted began to disappear, it would move southward, and would continue its march as the cold and severity of the winters increased. During the continuance of the ten or twelve thousand years of Arctic conditions it would find in Southern Europe and elsewhere places where it could exist. At the end of the cold period, and when the climate again began to grow mild and equable, it would retrace its steps northward. There is, however, little doubt that during the severity of a glacial period, and when necessarily confined to a more limited area, its numbers would be greatly diminished. There is every reason for believing that the Mammoth outlived all that succession of cold and warm periods known as the Glacial epoch proper, and did not finally disappear till recent post-glacial times.

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* Geol. Mag., June, 1881.

It was probably about the commencement of a cold period, and before the Mammoth had retreated from Northern Siberia, that those individuals perished whose carcasses have been found frozen in the cliffs. The way in which they probably perished and became imbedded in the frozen ice and mud, has, I think, been ingeniously shown by Dr. Rae.*

Arctic America during Interglacial times.—We have seen that the eastern continent in Pleistocene times enjoyed in the Arctic regions interglacial conditions of climate. It is true that on the western continent we have not in Arctic regions such clear and satisfactory evidence of an interglacial period. But it would be rash to infer from this that the western continent was, in this respect, less favored than the eastern. That we should find less evidence at the present day of former interglacial periods in Arctic America than Arctic Asia, is what is to be expected, for the glaciation which succeeded interglacial periods has been far more severe in the former region than in the latter. The remains of the Mammoth have, however, been found in Arctic America, in ice-cliffs at Kötzebue Sound, under conditions exactly similar to those of Siberia.

In Banks's Land, Prince Patrick's Island, and Melville Island, as in Northern Siberia, full-grown trees have been found in abundance at considerable distance in the interior, and at elevations of two or three hundred feet above sea level. The bark on many of them was in a perfect state. Captain McClure, Captain Osborn, and Lieutenant Mecham, by whom they were found, all agreed in thinking that they grew in the place where they were found.

It is true that more recent Arctic voyagers have come to the conclusion that these trees must have been drifted down the river from the south. There can be little doubt that the greater part of the wood found there, as in Siberia, is driftwood. But may there not be, also, as in Siberia, two kinds of wood?—a "Noashina" and a "Adamshina," a kind which was drifted and another kind which grew on the spot. This is a point which will require to be determined.

That so little has as yet been done in the way of searching for such evidence of interglacial periods, is, doubtless, in a great measure due to the fact that most of those, if not all, who have visited those regions entertained the belief that there is an *à priori* improbability that a condition of climate which would have allowed the growth of trees in such a place prevailed so recently as Post-tertiary times. Even supposing those Arctic voyagers had considered the finding of interglacial deposits a likely thing, and had in addition made special search for them, the simple fact that they should have failed to find any trace of them could not, as we have already shown, be regarded as even presumptive evidence that none existed. Take Scotland as an example. Abundant relics of interglacial age have there been found from time to time; but among the many geologists who visit that country year by year, how few of them have the good fortune of discovering a single relic. In fact, a geologist might search for months, and yet fail to meet with an interglacial deposit. The reason is obvious. The last ice-sheet, under which Scotland was buried, was so enormous as to remove every remnant of the preceding interglacial land-surface, except here and there in deep sheltered hollows, or in spots where it may happen to have been protected from the grinding power of the ice by projecting rocks. But all those places are now so completely covered with bowlder-clay and other deposits that it is only in the sinking of pits, quarries, in railway-cuttings, and other deep excavations that traces of them accidentally turn up. Now if it is so difficult to find in temperate regions, in a place like Scotland, interglacial remains, how much more difficult must it be to meet with them in Arctic regions where the destructive power of the ice must have been so much greater.

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* Phil. Mag. for July, 1874, p. 60.

Something like indications of an interglacial period appear to have been found by Professor Nordenskjöld in Spitzbergen. "In the interior of Ice-fjord," he says, "and at several other places on the coast of Spitzbergen, one meets with indications either that the polar tracts were less completely covered with ice during the glacial era than is usually supposed, or that, in conformity with what has been observed in Switzerland, interglacial periods have also occurred in the polar regions. In some sandbeds not very much raised above the level of the sea one may, in fact, find the large shells of a mussel (*Mytilus edulis*) still living in the waters encircling the Scandinavian coast. It is now no longer found in the sea around Spitzbergen, having been probably routed out by the ice-masses constantly driven by the ocean-currents along the coasts."*

This testimony is the more valuable as it is given by an experienced geologist so much opposed to the theory of interglacial periods. A more special and thorough search of those beds might probably reveal further indications of interglacial age.

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* "On former Climate of Polar regions," Geol. Mag., Nov. 1875, p. 531. See also "Geology of Spitzbergen," Geol. Mag., 1876, p. 267.

Was Greenland free from Ice during any of the Interglacial Periods?—There is nothing whatever improbable in the supposition that during some of the earlier interglacial periods, when the eccentricity was about a maximum, the ice might have completely disappeared from Greenland, and the country become covered with vegetation.

Mr. Wallace thinks that the existence at present of an ice-sheet on Greenland is to be explained only by the fact that cold currents from the polar area flow down both sides of that continent. He further thinks that could these two Arctic currents be diverted from Greenland, "that country would become free from ice, and might even be completely forest-clad and habitable."*

I am inclined to agree with Mr. Wallace in thinking that the withdrawal of the two cold currents in question would effectually remove the ice. We know that Greenland is at present buried under ice, as has been shown on former occasions, simply because there happens to be about two inches more of ice annually formed than is actually melted. It certainly would not require any very great change in the present physical and climatic conditions of things to melt two additional inches per annum. If this were done the ice would ultimately disappear. A simple decrease in the volume of the two currents might possibly bring about such a result. A cause more effectual would, however, be an increase in the temperature and volume of the Arctic branch of the Gulf-stream.

NOTE.—This will probably be my last paper on questions relating to geological climate. There are many points I should have wished to consider more fully, but advancing years and declining health have rendered it necessary for me to abandon the subject altogether in order to be able to finish some work, in a wholly different field of inquiry, which has been laid aside for upwards of a quarter of a century.

* 'Island Life,' p. 149.

Art. XLII.—*Notes on some apparently undescribed forms of Fresh-water Infusoria. No.* 2 ;* by Dr. Alfred C. Stokes. With Plate III.

The subjoined fresh-water Infusoria which, so far as I am able to ascertain, have not been previously observed and are consequently undescribed, have, with a single exception, been obtained from the shallow ponds and streams of New Jersey. That they are restricted to that locality, however, is not probable.

Physomonas vestita, sp. nov.

Body subglobose, the anterior truncation obsolete; the entire surface clothed with a thin, mucilaginous, finely granular investment, through which penetrate numerous delicate, flexible, ray-like bodies apparently adherent to all points of the surface; endoplasm granular; long flagellum flexible, the distal extremity arcuately curved, twice the diameter of the body in length, the secondary one one-fourth that length, and vibratile; pedicle filiform, flexible, four times the diameter of the body in length; contractile vesicles two, situated close to and slightly in advance of the median line; a linear, slightly curved band or groove near the frontal margin of the body. Diameter of the zooid $\frac{1}{1666}$ inch. Habitat.—Pond-water, with Myriophyllum. Solitary.

In two particulars this species differs from the hitherto single known member of the genus:—in the absence of the truncated anterior border, and in presence of a linear, dark-bordered band or depression near the frontal margin, as exists in Spumella. In structure, habits and other essential characteristics it is a Physomonas. Influenced, however, by what I at first interpreted to be ray-like pseudopodia, I was not disposed to relegate it to any previously instituted genus, but felt compelled to form for its reception a new generic niche in the order Radio-Flagellata. Subsequent study, however, dispelled that idea and proved the animalcule to be an undescribed species of Physomonas. The radiating bodies project from all parts of the cuticular surface, and possess some of the characters of what Dr. Leidy, in his monograph on the fresh-water Rhizopoda, has styled "cils," being, in this instance permanent, non-vibratile, hair-like prolongations which need only to assume a rapid movement to become the familiar cilia. These spicular bodies have no circulation of their substance as do true pseudopodia emitted by the Rhizopoda and some of the lowest of the Infusoria; they are not retractile, neither do they take any part in the capture of food, as in members of the Radio-Flagellata where the nutritive particle, dashed down by the short flagellum, is seized by one or more of the pseudopodic projections and drawn into the body. With this form the food, thrown down by the action of the short flagellum, enters at any part of the surface, usually near the base of the flagella, where the part opens, the mucilaginous investment and the adherent spicules moving outwardly on what appears to be a delicate cuticle, a wave-like outflow of the endoplasm surrounds the particle and draws it into the body enclosed in a large drop of water. In length these cuticular spicules are little shorter than the short flagellum.

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* See this Journal, xxviii, 39, July, 1884.

The nucleus is indistinct and presumably centrally placed, although it was not positively identified. The two contractile vesicles pulsate alternately, and are distinctly apparent. The animalcule is shown in fig. 1, Plate III.

Bicosœca lepteca, sp. nov.

Lorica sub-cylindrical, three times as large as broad, truncate and slightly narrowed anteriorly into an inconspicuous neck, somewhat inflated centrally, thence gradually tapering to the acute point of attachment to the pedicle whose length is equal to the greatest width of the lorica; animalcule ovate, with the usual oblique frontal border, the two diverse flagella and the eccentrically attached contractile ligament, the extended body projecting but a short distance beyond the lorica; pulsating vesicles two; nucleus sub-centrally placed. Length of lorica $\frac{1}{1500}$ to $\frac{1}{1800}$ inch; width $\frac{1}{4500}$; height of pedicle $\frac{1}{4500}$. Habitat.—Pond-water, with Myriophyllum and Algæ.

This minute creature is among the largest, if not the largest of the genus, the loricæ of the hitherto known species measuring from the $\frac{1}{3000}$ to the $\frac{1}{2500}$ inch in height, the one usually extending to the $\frac{1}{2500}$ inch is at times found to produce a sheath $\frac{1}{1500}$ inch high, thus in its most luxuriant growth only equalling the ordinary proportion of *Bicosœca lepteca*, which consequently becomes the most gigantic of those yet recorded. From the only sweet-water species, *B. lacustris* J.-Clk., hitherto observed as a resident in American lakes, it differs so widely that to designate the points of dissimilarity would necessitate an extended description of the form here used in comparison. The loricæ, as is so common with those of the Vaginicolina, frequently change from the hyaline condition of youth to a semi-opaque chestnut-brown coloration of maturity and old age; and occasionally a deserted lorica is observed that, judging from this change of tint, is neither young nor mature, for the posterior half has assumed a translucent, chestnut hue while the remaining portion is as colorless as when first secreted. Arguing from this alteration, it is probable that the chemical composition of these sheaths is similar to those of the Vaginicolina, and the pedicles of some of the Choano-Flagellata, in all of which the change has been observed.

The species is shown in fig. 2.

Bicosœca leptostoma, sp. nov.

Lorica elongate-ovate or subfusiform, three times as long as broad, tapering anteriorly to a short neck-like portion, the aperture very narrow, the margins not everted, the posterior half tapering to the pedicle whose length is equal to one-half the greatest width of the lorica; animalcule ovate or subpyriform, occupying the anterior half of the sheath, being entirely enclosed, with the exception of the long, lip-like projection extending beyond the aperture; contractile vesicles two, posteriorly placed; nucleus anteriorly situated. Length of lorica $\frac{1}{1500}$ inch; height of pedicle $\frac{1}{9000}$. Pond-water; attached to Myriophyllum and Algæ. Gregarious.

This form most closely resembles that of the salt-water *Bicosœca tenuis* S.-K., and may be considered its fresh-water representative; resembling it also in the proportion borne by the width of the lorica to the length, and in the short distance to which the extended animal protrudes itself, but differing in size, length of pedicle and in the form of the enclosed zooid. The narrow, lip-like prominence being the only portion of the body which extends beyond the lorica, it receives and accepts or rejects all food particles thrown upon it by the flagella. It is usually held arcuately curved, unwelcome particles commonly traversing its concavity to escape, as though urged by a strong current, acceptable matters being engulfed by an advancing wave of sarcode. The animalcule is shown in fig. 3.

Bicosœca longipes, sp. nov.

Lorica ovate, twice as long as wide, slightly narrowed anteriorly, the margin not everted, tapering towards its junction with the pedicle which is four or five times as long as the lorica; enclosed zooid subspherical, extending but a short distance beyond the aperture; contractile vesicles two, posteriorly situated. Length of lorica $\frac{1}{3250}$ inch. Habitat.—Pond water; attached to Myriophyllum. Solitary.

With this and the preceding species the long flagellum, when the retracted infusorian withdraws it into the lorica, is spirally coiled as is usual with all the members of the genus, but the great diameter of the coil is here horizontal, so that it appears to rest by its greatest width on the zooid's frontal border. Since my attention was especially called to this feature I have not obtained a specimen of the usually abundant *B. lacustris* J. Clk., but with it, I infer from Saville-Kent's remark, that the longest diameter of the coiled flagellum is vertical, so that the narrow edge of the spring-like spiral rests on the anterior border of the zooid. Kent's figure exhibits it correctly as it occurs in the present species and the two preceding when about to uncoil itself, the spiral then assuming a vertical position, but he remarks that "the longer of the two flagella, as shown in fig. 17, is thrown into an elegant spiral coil, reminding the observer of the spirally retracted proboscis of a butterfly." This is assuredly not the case in the three species here described.* The lorica and extended animalcule of *B. longipes* are shown in fig. 4.

Stylobryon Abbotti, sp. nov.

Loricæ conical-campanulate, widest anteriorly, not everted, tapering without constriction to the pedicle, twice as long as broad, and united to each other by pedicles about one-half as long as a single lorica, into the cavity of which they are continued, becoming gradually attenuated to their extremity, each lorica usually bearing two loricæ which are apparently sessile on the antero-lateral borders of their supporting sheath; primary foot-stalk about six times as long as a single lorica; enclosed animalcule not conspicuously changeable in shape, ovate or subspherical, the projecting lip short; flagella two, the longer scarcely extending beyond the orifice of the lorica, to the posterior portion of which the infusorian is confined by a short, filamentous, contractile ligament; pulsating vesicle single, posteriorly placed; nucleus subcentral. Length of individual loricæ $\frac{1}{1500}$ inch; of primary pedicle $\frac{1}{250}$ inch. Habitat.—Pond water; attached to filamentous Algæ or other fine vegetable fibres.

This polythecium, unlike that of *Stylobryon petiolatum* (Duj.) S.-K., which it most resembles, is subject to but little variation in its mode of colony-building. As shown in fig. 5, from which most of the zooids have been intentionally omitted, its usual method is to erect a cluster of tapering, bell-shaped loricæ by attaching two to the frontal borders of the primary sheath and continuing in this manner until the polythecium is completed. Occasionally, however, the first or supporting lorica bears three, the third being centrally placed, but, so far as observed, not further continuing the tripartite arrangement. The number of loricæ composing the polythecium takes a considerable range with age. No colonies have as yet been noted with less than six, neither has it yet been my good fortune to obtain one of these beautiful polythecia exhibiting more than the thirty-one which composed the colony shown in the figure.

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* Since writing the above I have seen Prof. Clark's original article in the "Memoirs of the Boston Society of Natural History," i, 1866, where, speaking of *B. gracillipes*, he says: "The only time that the flagellum abandons its rigid deportment is either when it is assisting the lip to seize the food, or during the spasmodic retrocession of the body. In the latter case it is abruptly retracted and coiled transversely within the calyx close down to the truncate front of the body." And of the flagellum of *B. lacustris* he says, "its flexibility is exhibited in the same way as in the other species."

The loricæ, like those of *Bicosœca lepteca* referred to on a previous page, are remarkable for the great apparent facility with which they change their hyaline condition to a translucent but deep chestnut-brown coloration. As in the Bicosœca, again, this is occasionally accomplished so early that in some polythecia, although the terminal loricæ have seemed to be incomplete, yet their posterior portions have become brown while the remainder, apparently in process of formation, has been colorless and transparent.

In general appearance this form resembles *Stylobryon petiolatum*, differing, as has been stated, in being less variable in the manner of building up its polythecium, in the shape and posterior position of the enclosed zooids, in the more conical form of the individual loricæ, and especially in their much smaller size, those of *S. petiolatum* measuring from $\frac{1}{500}$ to $\frac{1}{800}$ inch, while with the present species none greater than $\frac{1}{1500}$ inch have been observed.

It gives me pleasure to dedicate the species to my friend Dr. Charles C. Abbott, the well-known archæologist and naturalist, near whose farm the beautiful colonies were originally obtained. It seems appropriate that the species should bear his name, since its habitat was the still waters of that attractive region, the vertebrate life of whose upland and meadow Dr. Abbott has described so charmingly in his "*Rambles of a Naturalist about Home*," and on whose fields and hillsides he has discovered so many evidences of paleolithic occupants, and so many specimens of their handiwork.

Tillina helia, sp. nov.

Body somewhat bean-shaped, or sub-elliptical with an anteriorly situated ventral concavity; twice as long as broad, slightly widest posteriorly, longitudinally striate and entirely ciliate, the cilia of the posterior extremity longest and most conspicuous, the anterior and posterior borders evenly rounded, the former somewhat curved toward the ventral aspect; oral aperture elongate-ovate, obliquely set within the anterior ventral concavity, followed by short, recurved, ciliated pharynx; contractile vesicle single, situated back of the body-centre in the right-hand lateral border, often leaving after systole a rosette of small vacuoles which finally coalesce; anal aperture opening on the ventral surface near the posterior extremity; nucleus large, ovate, subcentrally situated. Length of body $\frac{1}{800}$ inch. Habitat. Standing water, with Algæ.

Although the nucleus is correctly referred to as being subcentrally placed, its position in reference to any special region is not constant. At times it is near and central to the dorsum, at others it is almost exactly in the center of the body, and occasionally it is found near the middle of the ventral surface. The majority of individuals examined had this important organ situated as shown in fig. 21, where it would seem to be in its normal position.

DEREPYXIS (*δερη, neck, πυξις, box*), gen. nov.

Animalcule single, inhabiting a pedicellate, flask-shaped lorica to which it is in no way attached; zooid subspherical, enclosing two laterally disposed color-bands; flagella two, subequal, rising from the center of the anterior margin; contractile vesicles two; pharynx presumably represented by a small, colorless space at the base of the flagella.

This is near Stein's Chrysopyxis, resembling it in the form of the enclosed zooid, its biflagellate condition and its entire freedom within the protecting sheath; but differing in the constantly pedicellate character of the lorica, the latter, in the genus instituted by the German authority, being sessilely attached to its support. The development of a conspicuous footstalk to the sheath of Derepyxis is sufficient to relegate its possessor to a new genus. The infusorian that habitually produces a pedicle before it secretes its lorica, is a little higher in the scale than one that develops a sessile lorica.

Derepyxis amphora, sp. nov.

Lorica flask-shaped, transparent, two and one-half to three times as long as wide, narrowed posteriorly and produced anteriorly in a cylindrical neck-like portion one-fifth the entire lorica in length, its circular border truncate, not everted; pedicle short, thick, about one-tenth the length of the lorica; enclosed animalcule occupying the center of the sheath, subspherical, somewhat compressed, the anterior border slightly pointed, this part usually colorless; the endoplasm with two, broad, lateral, greenish-yellow bands; flagella even, diverging, and projecting for a considerable distance beyond the lorica; nucleus not observed; contractile vesicles two, postero-terminal, pulsating alternately. Reproduction by longitudinal fission. Height of lorica $\frac{1}{900}$ inch; length of enclosed zooid $\frac{1}{1800}$ to $\frac{1}{2000}$. Habitat.—Pond water; attached to algal filaments.

This interesting creature occurs in considerable numbers on the finer filamentous fresh-water Algæ. The lateral color-bands are very broad, often appearing to surround the entire body, a high amplification in such instances being required to demonstrate the narrow chink of colorless endoplasm separating them longitudinally. The tint of these bands is a greenish-yellow deeping to a darker green at the periphery. The infusorian is conspicuously gregarious in habit. It is shown in fig. 6.

Derepyxis ollula, sp. nov.

Lorica broadly flask-shaped, one and one-half times as long as broad, centrally subspherical, slightly narrowed at the posterior extremity, the neck-like portion subcylindrical, one-fourth as long as the entire lorica, the circular border not everted; pedicle short, stout, in length about one-eighth the entire height of the lorica; enclosed zooid spherical, the anterior border rounded; lateral color bands as in *D. amphora;* flagella of equal length; contractile vesicles posteriorly located, but not terminal. Height of lorica $\frac{1}{1125}$ inch; diameter of enclosed zooid $\frac{1}{2250}$. Reproduction by longitudinal fission. Habitat.—Pond water; attached to confervoid filaments. Solitary or few together.

This infusorian conspicuously differs from the preceding in the shape and size of the lorica, and in the more spherical contour of the enclosed zooid with its evenly convex frontal border. The tint of the color bands is about that of *D. amphora;* they are similarly broad, and also usually obscure the colorless central sarcode. The lorica and enclosed zooid are shown in fig. 7. It does not so abundantly ornament the supporting algal filament as does *D. amphora*, neither is it so frequently met with in the habitat preferred by both.

Chilomonas ovata, sp. nov.

Body evenly ovate, persistent in shape, once and one-half to twice as long as wide, rounded posteriorly, somewhat narrowed anteriorly, the frontal border obscurely bilabiate, the endoplasm enclosing numerous dark-bordered corpuscles; flagella subequal, exceeding the body in length, inserted close together at the anterior apex; contractile vesicles two, pulsating alternately, situated near the frontal margin; nucleus posteriorly placed. Length of body $\frac{1}{3250}$ to $\frac{1}{1800}$ inch. Habitat.—The bacterial pellicle on the surface of vegetable infusions.

This form was taken in abundance from the habitat mentioned, in company with a greater number of its comparatively gigantic relative, the *Chilomonas paramœcium* Ehr. It is readily distinguishable from the latter by its much smaller size, it indeed being the most minute fresh-water species yet recorded, by its long flagella, and particularly by the presence of two contractile vesicles, and the almost obsolete bilabiation of the frontal apex. The latter is so obscure, the border at times even appearing to be slightly pointed, and the contractile vesicle is so conspicuously double, that I have with some hesitation identified the infusorian as a member of the genus Chilomonas, but the other characteristics are so marked that it would seem preferable to slightly modify the generic diagnosis rather than to institute a new genus for its reception.

The dark-bordered corpuscles so numerous within this and *C. paramæcium*, are of an amylaceous nature, as is proved by their change to an intensely blue color when the animalcule is killed with iodine. The nucleus is usually so completely hidden by these superposed starchy corpuscles that it is positively located with difficulty. In several individuals, however, these bodies have chiefly collected in the anterior portion of the zooid, in which cases what I have taken to be the nucleus has been left in an almost subterminal position. The mature animalcule is shown in fig. 8.

Reproduction is accomplished by conjugation followed by encystment and quadruple subdivision. Union takes place by the adhesion of the two frontal borders, the body contents of one animalcule slowly passing into and mingling with those of the other, the latter gradually assuming a spherical form and exhibiting four actively moving flagella, as in fig. 9. That the zooids possess a distinct cuticular investment is proved during this process of protoplasmic transfer, for at that time, as shown in fig. 10, the posterior portion of the cuticular coat is left empty, the space slowly increasing in size until after the conjugation has been consummated; the completely vacated cuticular sac adheres to the quadriflagellate spherical result of the genetic union, as shown in fig. 9, whence it gradually melts away. The ultimate fate of the flagella I could not positively determine; my impression is, however, that they are absorbed. They remain visible and active for a considerable time after conjugation; in one instance a single flagellum did not entirely disappear until fission in one plane had been almost completed. The cuticular surface of the united animalcules, swollen into a sphere, becomes the cyst wall within which quadruple division takes place, the four young zooids thus formed differing from the mature infusorian apparently in size only.

In a single instance, previous to the union of the frontal borders, the four flagella became fused into two, after which I suppose the reproductive process proceeded as just described, but as I neglected to supply the water lost by evaporation from beneath the cover glass, the advancing wave swept them from the field and they were lost. Conjugation and encystment have not been observed in the other species of the genus, longitudinal fission prevailing generally.

Loxophyllum flexilis, sp. nov.

Body irregularly ovate, lanceolate or sub-triangular, three times as long as broad, transparent, lamellate, very soft and flexible, widest posteriorly, tapering toward the anterior extremity which is somewhat curved toward the ventral aspect; the posterior margin obliquely and undulately rounded, the ventral border concave, the dorsal one irregularly convex, its posterior region bearing two small, conical elevations; the cuticular surface furrowed lengthwise, often thrown into longitudinal folds, entirely ciliated, the cilia of the anterior extremity somewhat longest and most conspicuous; oral aperture opening subterminally on the ventral surface; contractile vesicles three or more, the largest one postero-terminal, the others small and scattered; nucleus moniliform, the nodules irregularly ovate, centrally situated; trichocysts apparently wanting. Length of body $\frac{1}{300}$ inch. Habitat.—The bacterial pellicle on the surface of an infusion of dead leaves.

The movements of this infusorian are slow and even, with uncertain changes from one side to the other, and with equally unexpected contortions consisting of indescribable twistings and foldings of the body. The creature's remarkably irregular outline is made more so by the two little projections on the posterior part of the dorso-lateral border. These are constantly present, but vary somewhat in size and form. What utilitarian purpose they may subserve it is difficult to conjecture.

In a single instance I have observed what appeared to be genetic union of two of these animalcules. The combination resulting from this conjugation was almost indescribably irregular, being thrown into numerous folds and plications and rounded projections, the entire creature exhibiting the most deliberate and grotesque writhings and twistings. The separate animalcules were not seen previously to this apparent union, and so long as I was able to follow the apparent combination, no change except of form took place. The normal contour of the infusorian is shown in fig. 11.

Spirostomum loxodes, sp. nov.

Body elongate-fusiform, flattened, six to seven times as long as broad, widest centrally, tapering slightly toward both the anterior and posterior extremities, the former rounded and curved toward the left, with a short beak-like projection, the posterior margin truncate; cuticular surface obliquely striate, the cilia of the anterior and posterior borders more conspicuous than those of the general surface; peristome field occupying about one-third of the length of the body; nucleus moniliform, the nodules ovoid; contractile vesicle extending through the entire length of the right-hand border, with a conspicuous posterior dilatation; anal aperture postero-terminal. Length of body $\frac{1}{85}$ to $\frac{1}{75}$ inch. Habitat.—Pond water in Western New York.

In external contour this creature bears a striking resemblance to Loxodes, and might readily be mistaken for a member of that genus when casually examined with a low power of the microscope. In its own genus it approaches nearest to *Spirostomum teres* C. & L., which is without the acutely pointed sinistral curvature of the anterior margin, and differing also specifically in the presence of a moniliform instead of a single ovoid nucleus, and in the proportion borne by the width of the body to the length.

Reproduction takes place by transverse fission probably following conjugation, as individuals have been repeatedly obtained in the latter condition, the union, as observed, being effected by the mutual adhesion of the peristome fields throughout their entire length. The free-swimming infusorian is represented in fig. 12.

Vaginicola leptosoma, sp. nov.

Lorica subcylindrical, three and one-half to four times as long as broad, slightly inflated centrally, thence rapidly tapering to the narrow, truncated base of attachment, the lateral borders of the posterior portion often undulate, the circular anterior margin not everted; animalcule attached to the lorica by a short pedicle, the extended body narrowly elongate-conical, projecting for from one-third to one-half of its entire length beyond the lorica border, the cuticular surface finely striate transversely; nucleus elongate, band-like. Length of lorica $\frac{1}{160}$ inch. Habitat.—Pond water; attached to Algæ.

The lorica in form resembles that of *Vaginicola attenuata* (From.) S.-K., but is just twice as large, besides differing in the proportion borne by the length to the width. The contracted body of *V. attenuata* is described as urn-shaped; the present species when in that condition is simply obovate. The surface of the former is smooth. The cuticular striations of *V. leptosoma* are distinctly marked. This ornamentation of the surface has not been observed on any of the previously known species. The nucleus is remarkably elongate, extending through nearly the entire length of the body. The lorica and extended animalcule are shown in fig. 13.

Cothurnia annulata, sp. nov.

Lorica ovate, two and one-half times as long as broad, the posterior one-fourth widest and somewhat inflated yet tapering to the pedicle and often undulate, the posterior margin conspicuously thickened at the point of attachment to the foot-stalk, the anterior three-fourths, tapering to the circular, truncated margin, which is not everted; pedicle short, slightly narrower than the extremity of the lorica, where it is apparently widened and continued through the thickened wall as a longitudinally striate prolongation or footstalk to the enclosed zooid; extended animalcule obconical, protruding but a short distance beyond the lorica, the cuticular surface transversely striate and bearing near its middle a narrow, transverse ring-like elevation or ridge. Length of lorica $\frac{1}{450}$ inch; greatest width $\frac{1}{1125}$; breadth of aperture, $\frac{1}{1500}$. Habitat.—Pond water; on Myriophyllum.

The enclosed animalcule here differs from all hitherto known species in the possession of a transversely striated cuticular surface, and the ridge-like elevation encircling the central portion of the body. These points alone are sufficient for diagnosis, although the lorica also differs in form from that of any previously described member of the genus. This with the extended animalcule are shown in fig. 14.

Litonotus vesiculosus, sp. nov.

Body elongate, sub-fusiform, produced posteriorly into a tapering, pointed, retractile tail-like prolongation equal to one-fourth the length of the entire body, and extended anteriorly into a narrow, flattened, flexible and extensile neck, about one-half the entire length of the body, its frontal border slightly dilated and widened and bearing trichocysts at the tip; dorsal region rounded, smooth, the ventral flattened, longitudinally furrowed and entirely ciliated; nuclei two, spherical, subcentrally located, and apparently without a funiculus; contractile vesicles numerous, small, scattered throughout the cortical layer of the body and extending in a series through the neck and tail-like prolongations; trichocysts scattered in the cortex of the center of the body; parenchyma of the entire animalcule slightly granular. Length of the extended body $\frac{1}{40}$ inch. Habitat.—Pond water; among Myriophyllum.

In form this resembles *Litonotus Wrzesniowskii* S.-K., but is undoubtedly distinct. The relative and proportionate length of tail and extensile neck to each other and to the central body, and the form of the caudal prolongation are very conspicuously different from that of the species dedicated to the Russian naturalist; and the trichocysts, instead of being arranged in a regular row at the border of the neck and obliquely directed, are scattered in no apparent order throughout the cortical layer of the central body and at the tip of the neck, but not elsewhere. This portion of the internal structure is of specific value. The chief diagnostic characters, however, in the internal structure, are the presence of very many minute, quickly and irregularly pulsating contractile vesicles scattered about the cortex, while in the animalcule most resembling it the pulsating vacuole is large, single, and located near the origin of the caudal extremity. From *Litonotus pleurosigma*, described by the writer in the American Monthly Microscopical Journal for July, 1884, for which it might perhaps be mistaken if observed only in its contracted state, it differs in greater extensibility of the neck and tail, in the absence of the funiculus between the two nuclei, and especially in the arrangement of the contractile vesicles, those of *L. pleurosigma* being disposed in two rows, one on each side of the body near the ventral surface, while with *L. vesiculosus* they are not only more numerous, but are scattered throughout the body cortex as well as through the tail and neck.

Reproduction is by transverse fission, the dividing plane passing between the nuclei which have previously separated so that, as fission proceeds, each part of the animalcule has a single endoplast. Each nuclear nodule then elongates, quite rapidly divides transversely, the parts separating and becoming subspherical with some rapidity, so that before the completion of the reproductive act, each infusorial moiety possesses two disconnected nuclei, as did the parent. The mature infusorian is shown in fig. 15.

Litonotus carinatus, sp. nov.

Body elongate-lanceolate, five to six times as long as broad, extensile to a linear or subcylindrical form with vermicular movements, transparent and flexible, the tail-like prolongation short, obtuse, the neck-like portion in the mature zooid not distinctly distinguishable from the body, the anterior extremity slightly curved toward the right, not dilated; entire dorsal aspect traversed lengthwise by a narrow, convex, keel-like elevation; the ventral surface longitudinally striate, entirely ciliate; oral aperture subterminal; nucleus double, subcentrally placed, the nodules ovate and apparently connected without a funiculus; contractile vesicle single, near the posterior extremity; trichocysts few, confined to the left-hand border of the anterior body-half. Reproduction by transverse fission. Length of body $\frac{1}{300}$ to $\frac{1}{250}$ inch. Habitat.—The bacterial pellicle on the surface of an infusion of dead leaves.

The infusorian is represented in its dorsal aspect in fig. 16. It was obtained in great abundance on and beneath the jelly-like layer of bacterial and fungoid growths covering the surface of an infusion of various kinds of leaves, forming for some time the prevailing animalcule. It cannot be easily mistaken for any other species of the genus.

Litonotus trichocystus, sp. nov.

Body elongate-lanceolate, flexible and extensile, six to eight times as long as broad, widest centrally, slightly tapering toward the anterior extremity which is somewhat curved toward the right hand and depressed, but not conspicuously distinguishable from the body proper; tail-like prolongation short, posteriorly rounded; ventral surface longitudinally furrowed, entirely ciliate; endoplasm usually coarsely granular; nucleus double, the nodules subspherical, subcentrally placed and connected by a funiculus; contractile vesicle single, near the posterior extremity; trichocysts large, numerous, principally confined to the anterior body-half and the posterior extremity, in the former being arranged in an obliquely directed series along the left-hand border, a cluster at the frontal margin, a few on the right-hand border, many scattered irregularly through the cortex of the center of this region, and an irregular cluster at the extremity of the caudal prolongation. Length of body $\frac{1}{150}$ to $\frac{1}{200}$ inch. Reproduction by transverse fission. Habitat.—With the preceding in a vegetable infusion.

Examined in dorsal or ventral optical section this infusorian to a certain extent resembles *Litonotus fasciola* (Ehr.) S.-K. It is, however, easily distinguishable by its shorter and less conspicuously flattened neck-like part, and especially by the number and arrangement of the trichocysts, which are constant and will constitute the chief structural character, aside from contour, by which the animalcule may be readily identified. It is delineated in its extended state in fig. 17. When contracted it becomes broadly lanceolate.

Chilodon fluviatilis, sp. nov.

Body irregularly ovate, one and one-half times as long as broad, widest and rounded posteriorly, the left-hand lateral border truncate, the anterior lip-like projection rounded and obscure; ventral surface longitudinally furrowed, entirely ciliate, the cilia of the frontal border the most conspicuous; adoral groove obscure or absent; nucleus large, ovate, subcentrally situated; contractile vesicles numerous, scattered, a single, large, terminal vacuole often developed at the posterior extremity. Length of body $\frac{1}{500}$ inch. Habitat.—The water of the Delaware River at Trenton, N. J.

This differs from all other forms in its shape, the straight left-hand margin, which is thus far characteristic of it, in the absence of the lip-like prominence and the adoral groove, and in its preference for water not entirely still. The specimens were taken with Algæ from a rapid stream which forms the waste weir of the feeder to the Delaware and Raritan canal, the water coming originally from the Delaware river, and at the point where the Chilodon was obtained returning to it once more, during its passage forming in the hollows of the rocks and among the little heaps of stones, small comparatively still pools where the oddly shaped creature was oftenest captured. It of course hardly lives and thrives in a foaming brook, nor stems the current of a miniature rapid, yet it seems to prefer a locality where the water is not placid as a mill-pond, although it will take kindly to quiet surroundings. I have preserved it in a vessel on my table for some weeks.

When under prolonged observation it frequently develops a large, postero-terminal vesicle in addition to the pulsating vacuoles constantly present, occupying the entire width of the terminal border and contracting at long intervals. The animalcule is shown in fig. 18.

Chilodon caudatus, sp. nov.

Body irregularly obovate, once and one-half to twice as long as broad, widest anteriorly, the frontal border and right-hand lateral margin rounded, the posterior extremity of the flat, entirely ciliated ventral surface tapering to an acute point, the symmetry of the left-hand lateral border interrupted by the sudden narrowing of the body, thus forming a conspicuous, acute, sinistrally projecting lip-like extension; the posterior extremity of the smooth, convex dorsal region produced in a short, conical, acuminate, free but motionless, spur-like prolongation; cilia of the frontal border longest and conspicuous; ciliated adoral groove distinct; oral aperture on the right hand side of the median line in the anterior body-half; contractile vesicles numerous, scattered; nucleus sub-spherical, coarsely granular, posteriorly located; anal aperture on the right-hand border near the posterior extremity. Length of body $\frac{1}{600}$ inch. Habitat.—Standing water, with *Azolla Caroliniana* Willd.

In other species a common characteristic of the dorsal region is to become suddenly elevated, and so merged into the general surface as to leave a comparatively flat margin or rim surrounding the lateral and posterior and often the frontal borders; but here, while this plane extension of the body exists laterally and at the rear, it is obscure or obsolete anteriorly, and the postero-terminal border of the dorsum is continued as an acuminate and rigid spur. This extension is not a mere narrowed portion adhering to the flattened region beneath, but a free and disconnected yet inflexible projection. That this has any other than an ornamental function I have not observed. It, with the prominent anterior lip, will render the infusorian readily recognizable. The dorsal aspect of the animalcule is shown in fig. 19, and a diagrammatic outline of the posterior portion in longitudinal section in fig. 20.

Dexiotricha (*δεξιος, on the right-hand side, τριχιον, a little hair*), gen. nov.

Animalcules free-swimming, persistent in shape, entirely ciliate, elongate-ovate or subreniform, rounded posteriorly; oral aperture ventral, followed by a short, entirely ciliated, pharyngeal passage; one or more fine, hair-like setæ projecting from the posterior extremity of the body, and a single series of flexible, setose cilia extending transversely across the anterior right-hand ventral and lateral borders from the margin of the oral aperture to the margin of the dorsal surface; nucleus ovate; contractile vesicle single; anal aperture posteriorly situated.

In several structural points, in one attribute especially, the infusorian for which this new genus is instituted differs from all known animalcules. Its ordinal position is with the Heterotricha, and when a systematic treatise shall be written on our American infusoria, it will probably demand the formation of a new family group for its reception. It approaches nearest to the Bursariadæ of Stein, but diverges widely from the members of that family in the absence of the conspicuous, excavate peristome field, and especially in the presence of the row of adoral cilia on the right-hand side instead of the left, and in the presence of a ciliated pharynx, a feature to be distinguished only under high amplification and the most favorable position of the infusorian and the direction of the illuminating ray. Furthermore, the possession of a posteriorly projecting, filiform seta would alone force it out of that group.

Dexiotricha plagia, sp. nov.

Body elongate-ovate, two and one-half to three times as long as broad, the whole surface bearing minute, hemispherical protuberances which give the infusorian, in optical section, a crenulate outline; both extremities rounded, the posterior one widest, the frontal one slightly curved toward the ventral aspect, the anteriorly placed ventral concavity thus formed occupied by the ovate oral aperture; pharynx short, slightly recurved, its cilia projecting beyond the oral aperture; cilia setose; a single series of flexible, somewhat curved, setose cilia extending from the right-hand margin of the oral aperture obliquely backward and transversely across the right-hand side of the body to the border of the dorsal surface; a single, long, filiform seta projecting from the posterior extremity; nucleus ovate, subcentrally placed; contractile vesicle single, spherical, situated near the center of the ventral surface, at the right of the median line; endoplasm enclosing numerous small corpuscles, apparently bi-concave; anal aperture on the ventral surface near the posterior extremity. Length $\frac{1}{450}$ to $\frac{1}{400}$ inch. Habitat.—An infusion of dead leaves. Reproduction by transverse fission.

The object of the unique, one-sided arrangement of the adoral cilia is to direct food particles to the mouth. When the animalcule is quietly feeding, the cilia of the general cuticular surface are all quiescent, with the exception of those on the right-hand side in advance of the adoral, lateral hedge of setose bristles. These alone being in motion, the currents which they produce carry the food particles against the stifly upheld cilia whose obliquely directed course turns the stream downward and forward to the oral aperture. The pharyngeal cilia project beyond the orifice in a comb-like fascicle only to be distinguished when the animalcule is resting and these appendages are motionless. The infusorian is shown in its right-hand lateral aspect by fig. 22, and the projecting pharyngeal cilia in fig. 23.

Trenton, N. J.

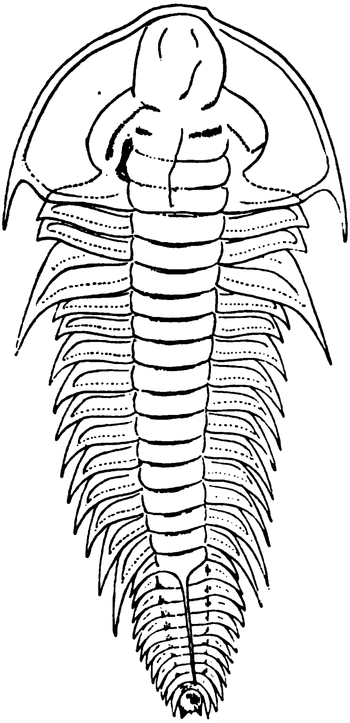
EXPLANATION OF FIGURES—PLATE III.

Fig. 1. *Physomonas vestita*, sp. nov. ×667.
Fig. 2. *Bicosœca lepteca*, sp. nov. ×1200
Fig. 3. *Bicosœca leptostoma*, sp. nov. ×1200.
Fig. 4. *Bicosœca longipes*, sp. nov. ×1200.
Fig. 5. *Stylobryon Abbotti*, sp. nov. ×600.
Fig. 6. *Derepyxis amphora*, gen. et. sp. nov. ×900.
Fig. 7. *Derepyxis ollula*, sp. nov. ×900.
Fig. 8. *Chilomonas ovata*, sp. nov. ×1575.
Fig. 9. *Ch. ovata* after conjugation with empty cuticular sac adhering.
Fig. 10. *Ch. ovata* in conjugation.
Fig. 11. *Loxophyllum flexilis*, sp. nov. ×260.
Fig. 12. *Spirostomum loxodes*, sp. nov. ×187.
Fig. 13. *Vaginicola leptosoma*, sp. nov. ×180.
Fig. 14. *Cothurnia anulata*, sp. nov. ×677.
Fig. 15. *Litonotus vesiculosus*, sp. nov. ×100.
Fig. 16. *Litonotus carinatus*, sp. nov. ×360.
Fig. 17. *Litonotus trichocystus*, sp. nov. ×350.
Fig. 18. *Chilodon fluviatilis*, sp. nov. ×400.
Fig. 19. *Chilodon caudatus*, sp. nov. ×720.
Fig. 20. *Ch. caudatus* in posterior, longitudinal optic section. Diagram.
Fig. 21. *Tillina helia*, sp. nov. ×270.
Fig. 22. *Dexiotricha plagia*, gen. et. sp. nov. ×530.
Fig. 23. *D. plagia*, showing ciliation of the pharynx.

ART. XLIII.—*Paleozoic Notes; New Genus of Cambrian Trilobites, Mesonacis*; by CHARLES D. WALCOTT, of the United States Geological Survey.

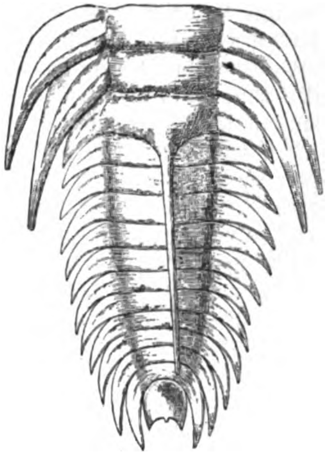
WHEN collecting fossils at Parker's quarry, in the town of Georgia, Vermont, in the season of 1883, we found a specimen of *Olenellus Vermontana* that appeared to have a body of another trilobite attached to it, back of the fifteenth segment. In 1884 Mr. E. Hurlburt, of Utica, N. Y., was collecting in the same locality and found a more perfect specimen that showed the true structure of the trilobite. It was discovered to be the type of an undescribed genus that appears to be intermediate between the genera Paradoxides and Olenellus, or a form in which the characteristics of Paradoxides are changing into those of Olenellus, the head and first fourteen segments being, in all particulars, the type of Olenellus, and the pygidium and ten posterior segments more the type of Paradoxides; the fifteenth segment represents the telson of *Olenellus Thompsoni.*

Fig. 1.



Type specimen, nat. size.

Fig. 2.



Enlargement of the posterior portion of Fig. 1, showing the spine on the 15th segment and the posterior 10 segments and pygidium.

The fifteenth segment fits snugly up against the fourteenth; the axial lobe is strong, and supports the base of a long, slender spine that, as now preserved, extends back to the pygidium; the base of the spine originates on the dorsal surface of the segment and also extends back so as to include the posterior margin, and causes the latter to curve back towards the center; the lateral pleuræ of the segment are short and, in structure, diminutive representatives of the large pleuræ of the segments anterior to the fifteenth.

The succeeding eleven posterior segments appear as though formed of a more delicate test than the anterior portions of the body, as they are much more flattened and compressed than the latter, and the plural grooves are almost obsolete. The pygidium is also small and delicate.

The body, back of the spine-bearing segment, appears as though belonging to a different animal, and looks more like that of a Remopleurides than either Olenellus or Paradoxides, but on a close examination, the pygidium is found to be much like that of *Paradoxides rugulosus*, and the free pleuræ bend back as in that species.

For this form the genus *Mesonacis* is proposed. One other species, *O. Howelli*, from Central Nevada, will probably be referred to it when the thorax and pygidium are found, as the head is very closely related to that of *M. Vermontana*.

The stratigraphic position of *M. Vermontana* is eleven hundred feet from the base of the Georgian Group, in the argillaceous shales at Parker's quarry, town of Georgia, Franklin county, Vermont, where it is associated with *Olenellus Thompsoni*, *Protocaris Marshi*, *Ptychoparia Adamsi*, etc.

The Georgian Group, in Vermont, consists of one thousand feet of magnesian limestone at the base, overlaid by from eight thousand to nine thousand feet of argillaceous shales in which great lenticular masses of limestone occur that carry a fauna similar to that of the shales. The base of the group and also its summit is at present unknown.

In Central Nevada, in an unbroken section, the Potsdam fauna, as found in New York and Wisconsin, occurs four thousand feet above the characteristic Georgian fauna, the intervening strata being entirely formed of limestones.

In a paper now in course of preparation by the writer, sections will be given , accompanied by lists of fossils, to show the relations of the St. John (Paradoxides), Georgian (Olenellus) and Potsdam (Dicellocephalus) Groups, or the Lower, Middle and Upper Cambrian.

In Bulletin 10, of the U. S. Geological Survey, the subgenus Salteria is proposed by the writer to include *Concoryphe Baileyi*, Hartt and *C. venulosa* Salter of the Lower Cambrian. The name had been previously given to a genus of trilobites (Mem. Geol. Surv. Brit. Organic Remains, Dec. xi, pl. vi) which necessitates the substitution of another subgeneric name for the species mentioned. Mr. G. F. Matthew (Trans. Roy. Soc. Canada, vol. xi, description of pl. i) having proposed the name *Bailiella*, that will replace Sateria as applied to *Conocoryphe* (*Baillie'la*) *Baileyi* of the St. John Group.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Specific Heat of the Elements at High Temperatures.*—In the course of their researches on the heat-relations of the explosion of gaseous mixtures, **BERTHELOT** and **VIEILLE** have been able to obtain the specific heat of the elementary gases at high temperatures. The experimental data were obtained by the combustion of cyanogen mixed with sufficient oxygen to convert it into carbon monoxide and nitrogen; two gases which have sensibly the same specific heat. From the pressure developed in the explosion, the temperature referred to the air thermometer was calculated; and from the total quantity of heat produced and the temperature, the specific heat (at constant volume) of the resulting gaseous mixture was derived, and hence the specific heat of either of the resulting gases. The results of six experiments of this sort were as follows:

Mixtures.	*Pressure developed, atm.*	*Heat evolved.*	*Temperature.*	*Specific heat* *Total.*	*For* N_2 *and* CO.
$C_2N_2+O_2$	25.11	126500 cal.	4394°	28·81	9·60
$C_2N_2+O_2+1\frac{1}{2}N_2$	20·67	126500	4024	31·46	8·39
$C_2N_2+O_2+2N_2$	15·26	126500	3191	39·67	7·93
$C_2N_2+O_2+\frac{7}{2}N_2$	11·78	126500	2810	45·05	6 67
C_2N_2+2NO	23·34	169800	4309	39·39	9·85
$C_2N_2+2N_2O$	26·02	168400	3993	42·17	8·43

It will be noticed that the numbers obtained are closely identical whether oxygen, nitrogen monoxide or dioxide is used to effect the combustion; thus at 4400° the specific heat with oxygen is 9·60 and with nitrogen dioxide 9·85, the ratio of N to CO being 1 : 1 by volume. At 4000°, with oxygen, the specific heat was found to be 8·39, and with nitrogen monoxide 8·43, the ratio of N to CO being 3 : 2 by volume. Moreover it will be observed that the specific heat increases rapidly with the temperature. This increase may be expressed as a function of the temperature by the empirical formula

$$C=6{\cdot}7+0{\cdot}0016(t-2800)$$

giving the following calculated value: at 2800°, 6·7; 3200°, 7·3; 4000°, 8·6; and 4400°, 9·3; the observed numbers being 6·7, 7·9, 8·4 and 9·6 respectively. These numbers may be adopted as expressing, at high temperatures and constant volume, the molecular specific heat of the simple gases, N_2, H_2 and O_2 as well as of the compund gas CO which is closely related to them. It is therefore evident that in passing from 0° to 4500° the mean specific heat of the elementary and simple gases nearly doubles. There is, however, another group of elementary and of compound gases to be considered. Regnault showed that the specific heat of chlorine, bromine and iodine were higher than that of the other elements, being 6·6 at constant volume instead of 4·8. The remarkable fact is that this specific heat is closely the same as that of the compound gases which are formed with a contraction of one-third in volume, as water, nitrogen monoxide and carbon dioxide. The data were obtained by combining chlorine and hydrogen in presence of an excess of one or the other of these gases; from which it appeared that the weight $\frac{2}{3}$ Cl was sensibly equal to that of H_2. The mean specific heat of chlorine at constant volume was found to be at 1800° nearly three times that of hydrogen; the latter being 5·1 and the former 15·3 nearly. Chlorine comports itself toward oxygen as ozone would do if it were stable and were formed with the evolution of heat.—*Ann. Chem. Phys.*, VI, iv, 66, Jan. 1885. G. F. B.

2. *On the Specific Heat of Water and of Carbon dioxide at High Temperatures.*—In a second paper, BERTHELOT and VIEILLE have given the results of similar calculations to determine the mean molecular specific heat of water and of carbon dioxide. The hydrogen was burned with oxygen either alone or mixed with nitrogen; in the latter case the specific heat of the nitrogen was subtracted. The following table gives the data and the calculated values obtained:

Mixture.	*T.*	*Total specific heat.*	*Sp. Heat of the N.*	*Mean mol. spec. heat of* H_2O *between* 0° *and* T°.
H_2+O	3240°	18·12		18.12
$H_2+O+\frac{1}{2}N$	2860	20·52	1·69	18·83
H_2+O+N_2	2543	23·08	6·26	16·82
H_2+O+2N_2	2180	26·93	11·36	15·57
H_2+O+3N_2	1798	32·05	15·21	16.84
H_2+N_2O	3133	25·09	7·20	17·89
$H_2+N_2O+N_2$	2601	30·60	12·70	17.90

The value given in the fifth experiment is not regarded as reliable as the others, since the large amount of inert gas present caused the combustion to be twelve times as slow. It will be observed that here also the specific heat increases with the temperature. The authors represent this increase by the empirical formula:

$$C=16{\cdot}2+0{\cdot}0019(T-2000)$$

Since the mean specific heat of water vapor between 130° and 230° is 6·65 at constant volume, it appears that it is more than doubled at 2000° and tripled at 4000°. On comparing the elementary specific heat of the vapor of water with that of its constituent elements, it appears that the former value is in excess of the latter at 2000° by 7·0 and at 4000° by 5·1. This excess represents a double work, first that of the molecular disaggregation of the compound gas, and second that of its chemical dissociation. The values obtained for carbon dioxide are given as follows:

Mixture.	*T.*	*Total specific heat.*	*Specific heat of the N.*	*Specific heat of the* CO_2.
$CO+O$	3334°	20·40		20·40
$CO+O+N$	2840	24·02	3·36	20·66
$CO+O+N_2$	2548	26·69	6·27	20·42
$CO+O+N_5$	1807	37·47	12·67	24·80
$C_2N_2+O_4$	4862	54 00	10·00	22.00
$C_2N_2+O_4+N_2$	4082	64·31	17·50	23·40
$C_2N_2+4N_2O$	3972	86.71	42·70	22·00

The fourth of these results is inaccurate owing to the extreme slowness of the combustion. The results with CO give a mean value of 20·5 between 0° and 2900°; those with CN give 22·5 between 0° and 4300°. Taking them together they may be represented by the empirical formula:

$$C=19{\cdot}1+0{\cdot}0015(T-2000)$$

This gives for the elementary specific heat of carbon dioxide at 2000°, 19·1; at 3000°, 22·1 and at 4000°, 25·1. The mean specific heat of this gas, therefore, more than triples, and the elementary specific heat quadruples, between 0° and 4300°.—*Am. Chim. Phys.*, VI, iv, 74, Jan., 1885. G. F. B.

3. *On the Action of Hydrogen peroxide on the Hydrates of the rarer earths.*—CLÈVE has studied the production of peroxides of the rarer earth-metals by the action of hydrogen peroxide upon their hydrates. Gelatinous precipitates were obtained which were washed by decantation, care being taken to avoid elevation of temperature, and in some cases dried over sulphuric acid. The oxygen was determined by dissolving the moist precipitate in dilute sulphuric acid and titrating the hydrogen peroxide thus formed with permanganate. In the dry precipitates the oxygen was determined by dissolving them in dilute sulphuric acid containing ammoniacal ferrous sulphate, and titering back with permanganate. Hydrogen peroxide gave the same result with both these methods; but cerium peroxide gave only half as much oxygen by the first method as by the second. The oxides of yttrium, lanthanum, samarium and didymium, whose formula is R_2O_3, act in the same manner with H_2O_2 and give peroxides of the formula R_4O_9, approaching R_2O_5. The oxides of zirconium and cerium, RO_2, give like titanic acid peroxides of the formula RO_3. The oxide of thorium, which belongs to the same group gives the peroxide R_2O_7.—*Bull. Soc. Chim.*, II, xliii, 53, Jan., 1885.

G. F. B.

4. *On the Determination of small quantities of Hydrogen sulphide in Gaseous mixtures.*—For the purpose of determining the quantity of hydrogen sulphide contained in mixtures of gases, OSMOND passes the gas to be tested through a series of bulbs containing a known quantity of titred solution of silver nitrate. As soon as the silver in the first bulb is entirely precipitated as sulphide, the precipitation begins in the second. If the quantity and strength of the silver solution in each bulb corresponds to a definite quantity of sulphur, say 0·01 per cent, then it is only

necessary at the end of the experiment to count the bulbs containing sulphide and the quantity of sulphur in the gas passed through the apparatus is at once known. Obviously the limit of accuracy in the method may be varied at will by varying the strength of the solution and the number of bulbs. If the test is to determine only whether the amount of sulphur is inferior to a certain maximum limit or not, two bulbs suffice. In the first the quantity of the reagent corresponding to this maximum is placed, if any blackening appears in the second, then there is an excess of sulphur over the permissible amount.—*Bull. Soc. Chim.*, II, xliii, 70, Jan., 1885. G. F. B.

5. *On the Atomic weight of Titanium.*—THORPE has made a series of elaborate and careful determinations of the atomic weight of titanium, using several methods. The product employed was, in the former set of experiments, titanium tetrachloride and in the latter titanium tetrabromide. In the first method a known quantity of the tetrachloride was placed in water, a quantity of silver slightly less than was required to completely precipitate it was dissolved in nitric acid and added to it, and then the remaining excess of chlorine estimated by means of a graduated solution. Eight experiments gave 48·06, 48·07, 47·98, 48·04, 48·04, 48·06, 47·94, 47·93. In the second method the precipitated silver was collected and weighed, and gave 47·99, 47·97, 48·00, 48·05, 48·05. The third method consisted in decomposing a known quantity of the tetrachloride with water, evaporating the product to dryness in a platinum dish and weighing the resulting titanic oxide. Six experiments gave 47·93, 48·00, 47·99, 47·96, 47·98, 47·94. In the second set of experiments, tetrabromide was used. When decomposed with water and titered with silver, the numbers obtained were 48·04, 48·06, 48·02, 48·03, 48·04. The weighed AgCl gave 47·95, 47·99, 48·19, 48·02. Conversion into titanic oxide gave 48·08, 47·97, 47·94. The number 48 which corresponds to Mendelejeff's table is the most probable atomic weight.—*J. Chem. Soc.*, xlvii, 108, Feb., 1885.

G. F. B.

6. *On Raffinose from Molasses.*—TOLLENS has examined a sample of sugar which crystallized out of a molasses prepared in a sugar house by precipitation with strontium hydrate. The crystals were separated by washing with alcohol from the adhering syrup, and purified by recrystallization. On analysis they afforded the formula $C_{12}H_{22}O_{11}+(H_2O)_3$. When the normal solution was examined in the polariscope, it gave a specific rotation $(\alpha)_D = 102·5$ —103°. When heated with sulphuric acid, the rotation fell to 45°. Fehling's solution is unaffected by it; but this solution is strongly reduced by it after the action of acids. It resembles the raffinose of Loiseau and the melitose of Berthelot.—*Ber. Berl. Chem. Ges.*, xviii, 26, Jan., 1885. G. F. B.

7. *Influence of an Electric Current in modifying the rate of thinning of a liquid film.*—Professors REINOLD and RÜCKER have discovered that an electric current passing through thin soap-

bubble films modifies in an interesting manner the rate of thinning of the films. The liquid employed was either a solution of potash soap in water or Plateau's *liquide glycérique* containing a certain proportion of niter to increase its conductivity. The films had the form of vertical cylinders—the upper and lower supports being of platinum. The films were blown with air which was first dried and then passed over some of the soap solution in a wide tube so that the condition of the air inside the tube was approximately that of the air on the outside. The electric current varied from about 100 microampères to half a microampère. The downward current was found to increase the rate of thinning of the film and the upward current to retard it.—*Phil. Mag.*, Feb. 1885, pp. 94–100. J. T.

8. *On the Conduction of Electricity in rarefied air.*—It has been maintained by **Edlund** in various papers that what is called a vacuum conducts electricity and that this conductivity increases with the degree of rarefaction. In the present paper he reiterates his reasons for believing that a discharge between platinum terminals in a Geissler tube could be obtained at a certain point of the exhaustion, if the effect of the electrodes in opposing the passage of the electricity into the gas could be overcome. He brings forward as evidence certain experiments in which a discharge is obtained through the glass sides of tubes containing rarefied air, through which no discharge could be obtained if platinum electrodes were used. *Phil. Mag.*, Feb. 1885, pp. 125–131. J. T.

9. *Measurement of Rotation of plane of polarization of liquids in a magnetic field.*—It has been suggested by various observers that the rotation of the plane of polarization of certain liquids placed in a magnetic field could be used as a measure of very strong currents. **Leo Arons** has redetermined Verdet's constant for this purpose, and believes that his result for distilled water at 23° C. and the wave-length of the sodium line, namely,

$$w = 0{\cdot}3767.10^{-6}\ \mathrm{cm}^{-\frac{1}{2}}\ \mathrm{g}^{-\frac{1}{2}}\ \mathrm{sec}$$

is within 0·5 per cent.—*Ann. der Physik und Chemie*, No. 2, 1885, pp. 161–182. J. T.

10. *On some Physical Properties of Ice.*—**Mr. Coutts Trotter**, fellow of Trinity College, Cambridge, has instituted some experiments on ice in an artificial grotto in a glacier near Grindelwald, in order to see, "if evidence of shearing under the influence of forces comparable to those which Canon Moseley admits to be capable of being produced by the action of gravity in a moving glacier could be obtained." Bars of ice were passed through holes in three parallel blocks of wood, nearly in contact with each other. The two outer blocks were hung to a frame, and a weight was suspended from the middle one. After the ice had hung for a few days, the apparatus was taken to pieces and the shear measured. In a final experiment a shear of about ·075 cm. was observed after the action for about seventeen days of a shearing force of rather more

than 200 grm. per square centimeter. Mr. Trotter is led to support the conclusions of Forbes, that glacier motion is that of a slightly viscous mass partly sliding upon its bed, partly shearing upon itself under the influence of gravity. Regelation also plays a part in the gradual passage of snow into ice and in the healing of crevasses.—*Royal Soc.*, Jan. 29; *Nature*, Feb. 5, 1885, p. 328.

J. T.

11. *Photographing the Solar Corona.*—Mr. C. Ray Woods, who was sent to Switzerland to photograph the solar corona according to the method devised by Dr. Huggins, sums up in the *Observatory* the results thus far obtained, as follows:

(1) As would be expected, the results are better than had been obtained in England, in spite of the red haze which has been always present round the sun, and which visitors to Switzerland have commented on in several of the scientific journals recently.

(2) Results on the same day are almost, if not quite alike, both *with* disk and *without.*

(3) The corona varies more or less from day to day.

(4) The clearer the sky the better the results.

(5) The series extends over a period of two months, a one month's results being free from effects that require elimination.

12. *Magneto- and Dynamo-Electric Machines*, with a description of Electric Accumulators, from the German of Glaser-DeCew; by F. Krohn, and specially edited with many additions by Paget Higgs, LL.D., etc. 301 pp. 8vo. London (Symons & Co.—The Specialists' Series, vol. i). This work is essentially a reproduction of the excellent little volume which formed No. 1 of the Elektro-technische Bibliothek, published in Vienna some two years since and at that time noticed in this Journal. The English editor has increased the value and scope of the volume by adding a number of chapters relating to the details in the construction and use of the machines. The subject at hand is too vast in its present development to allow of being treated thoroughly in a book of this size, but the reader will find in this volume a good selection of matter and will profit from its perusal.

II. Geology and Mineralogy.

1. ***Professor W. O. Crosby on the origin and relations of continents and ocean basins***, (Proc. Bost. Soc. Nat. Hist. for Nov., 1883; but recently printed.)—In this paper Professor Crosby discusses the contraction theory for the origin of continents and oceanic basins with some good arguments against the theory and others not so good, and arrives at the conclusion that the continental and oceanic areas have not always been essentially the same in limits as now, with relatively moderate submergences over the former and emergences over the latter, but that an Atlantic continent continued in existence through Paleozoic times, providing Paleozoic sediments for North America, and producing, in its sinking, pressure against the continent, which resulted in causing Appalachian foldings and uplift.

The writer's views are discussed in the paper though sometimes put in a form that is hardly recognizable. Professor Crosby, on the page before the last, says that Professor Dana, believing that the Atlantic existed with nearly its present outlines during Paleozoic time, and that the foldings of the Appalachian rocks were made by subsidence over the Atlantic area, thus "admits that the Appalachian sediments were separated from the Atlantic by at least one hundred and possibly several hundred miles of dry land;" "in other words, Professor Dana tells us that the sediments deposited in one ocean were plicated by the subsidence of the floor of another and entirely distinct ocean."

In reply to this remark I observe that the Appalachian area of subsidence through Paleozoic time—which ranged parallel with ridges of Archæan rocks and with the Atlantic border, was not "one ocean;" it was generally (according to evidence from the strata) a shallow part of the continental border, receiving its depositions in shallow waters. The Appalachian trough, or geosynclinal was, it is true, distant a hundred miles or more from the ocean's border; but I have suggested that it was probably separated by a low geanticlinal—emerged or slightly submerged; that the general contraction in the earth's crust, and especially of that part beneath the oceanic area, produced along the ocean's border, the geanticlinal as well as the geosynclinal, the two being concomitants in a system of flexures. I do not, therefore, see the appositeness of Professor Crosby's comparison which he adds in closing his paragraph: "This is very much the same as saying that the sediments now accumulating in the Gulf of Mexico will some day be compressed and folded by the subsidence of the bottom of the Pacific, Central America and Mexico remaining undisturbed as at present."

It is unnecessary to touch on other points of disagreement in the memoir. Moreover, I am led by the conflicting views of the best authorities with regard to the condition of the earth's interior to hold very loosely to any theory of mountain making. We wait for the physicists who believe in a solid earth to give us a theory which will have in view all geological facts. At present we get from them little more than an acknowledgment that no theory is yet in sight, or a disposal of the subject by passing it over to the "geologist," instead of recognizing that the facts, although geological, are physical and merit attention from physicists as much as the tides and more purely mathematical considerations.

The idea that the continents and ocean-basins have been in continued progress as such through the geological ages I regard as established upon as good evidence nearly as the fact that an animal is a result of slow development from a germ; and this evidence is similar in general nature, it consisting in direct knowledge of the successive conditions or steps of progress in the development. The facts from America are, as I have shown, the facts that make up the historical geology of the continent.

The Archæan dry lands are now believed to have had a wide distribution over eastern, northern and western America, as I point out in the more recent edition of my Manual (even New England having Archæan areas in both its eastern and western portions), and the regions within reach of abrading and degrading agencies were therefore of sufficient extent for the needed Paleozoic sediment-making. The sediments can, in many cases, be proved to have come from regions not far distant; the succession of mud-made rocks and those of beach or sand-flat origin, to have the relative positions of the beaches, sand flats and off-shore deposits of a growing continent; and one example of this I shall present in the following number of this Journal. Moreover, facts with regard to marine currents and wave-action, oceanic and sea-shore depositions, show that another continent in the Atlantic could have given no help had it existed. J. D. D.

2. *The Geology of Bermuda.*—Professor WM. N. RICE, of Middletown, Ct., has a valuable paper on this subject in Bulletin No. 25, U. S. National Museum, Washington, bearing date 1884, but issued the present year. It is accompanied by a map and other illustrations. Professor Rice after a special examination of the coral formations of the island agrees with Wyville Thomson in the conclusion that none of the rock above a level of fifteen feet is true under-water coral reef rock; it is either of beach or wind-drift origin, although in some parts 250 feet in height. Three changes of level appear to have occurred; that in which the original island subsided and the atoll was made; the second an uplift above the present level; the third a subsidence which led to extensive marine erosion of the wind-drift rock and the formation of the shore platform and cliffs. The supposed evidence of recent sinking is reviewed and the conclusion reached that none has taken place at least since 1609—the time of the shipwreck of Sir Thomas Gates and Sir George Somers. Darwin's theory of the origin of atolls appears to be sustained by the fact that at a distance of ten miles from the Bermudas in all directions, excepting the southwest, the depth is from 1500 to 2250 fathoms.

3. *C. D. Walcott on the Deer Creek Coal-field in Arizona.* (Senate Doc., No. 20, 48th Congress, 2d Session).—Deer Creek valley is about 13 miles south of the San Carlos agency, between two spurs of the foot-hills sloping down from Mount Trumbull to the Gila. Mr. Walcott states that in a section across the upper end of the coal field there is rhyolyte to the north and andesyte to the south. The northern boundary of the valley consists of a belt of Carboniferous limestone 1200 feet thick; south of this occur Cretaceous sandstone, clays and coal seams, nearly 3700 feet in thickness, apparently conformable to the underlying Carboniferous. There is also a band of Devonian limestone. The rhyolyte and andesite outflows were subsequent to the erosion of the valley.

The coal beds are in sandstone referred to the Cretaceous; two beds have each a thickness of about ten inches clear coal. The coal is bituminous, one analysis by Mr. Whitfield obtaining fixed carbon 60·85, volatile combustible matters 17·50, moisture 0·56, ash 21·09=100.

The fossils of the Carboniferous limestone determined by Mr. Walcott include *Fusulina cylindrica*, *Productus semireticulatus*, *Spirifera camerata* and other species. The coal shales, according to Mr. Lester O. Ward, contain remains of *Sequoia*, *Sabal*, *Phragmites*, *Myrica*, *Viburnum*, and other kinds.

4. *Crinoids with Articulating Spines.*—Dr. G. J. HINDE, in the Annals and Magazine of Natural History for March, describes and figures fine specimens of a Crinoid from Arkona, Province Ontario, Canada, having articulating spines. He refers to a paper by Professor H. S. Williams in the Proceedings of the American Philosophical Society for 1883, on a species of the kind—the first discovered—which this author referred to the new genus *Arthroacantha.* As this name essentially had been used in 1854 by Schmarda for a genus of Rotatoria, Dr. Hinde substitutes *Hystricrinus*, and names his species *H. Carpenteri*, after Dr. P. Herbert Carpenter.

The remarkable fact is mentioned (and figured) that three of the eleven specimens obtained have a shell of the genus *Platyceras* Conrad, covering almost entirely the vault of the Crinoid, and with the same position in all; in one the shell is *P. erectum* Hall, in the others, a small variety of *P. dumosum* Conrad.

5. *Creation of Continents by the Ocean Currents;* by J. STANLEY GRIMES. 116 pp. 12mo. Philadelphia, 1885 (J. B. Lippincott & Co.).—The author aims to show that the three pairs of ocean-basins—those of the North and South Atlantic, Pacific and Indian ocean—were produced through the weight of the sediment collected over the ocean's floor by three pairs of elliptical currents; that the sinking of the basins drove under the interoceanic crust the fluid or plastic rock beneath, and so made the three pairs of continents; that the elliptical oceanic currents flowed about an east and west major axis between the equator and the 45th parallel, and that the southern ellipses were about 50° in longitude east of the northern.

6. *Note on the Sandstones of Taquamenon Bay, Lake Superior;* by N. H. WINCHELL.—The editorial note of this Journal, to which Professor Irving takes exception in the March number, page 258, was so worded in its relation to the subject under consideration as to allow an erroneous inference as to the opinion of the writer respecting the age of the sandstones of Taquamenon Bay. This inference having been taken by Professor Irving he has taken considerable trouble to show that I am wrong in holding such a (presumed) opinion. Professor Dana quotes correctly from my tenth annual report (page 133), and if Professor Irving had consulted the same page he could have seen that the italic "*if*" which introduces Professor Dana's quotation throws almost the force of a negative against the inference which he assumes as

legitimate; and that really the argument of the whole paragraph from which the quotation is made is intended to show such a negative. The word "conspicuous" in that paragraph is a misprint for calciferous, as noted in the errata.

Minneapolis, March 4, 1885.

7. *Grand Atlas of the Second Geological Survey of Pennsylvania;* J. P. LESLEY, State Geologist, Division I. County Geological Maps, Part I. 50 sheets imperial folio. Harrisburg, 1885.—A grand atlas in fact is this first part of the atlas of the Pennsylvania Survey. The best style of map-making and map-coloring have been employed in illustration of the results of excellent detailed geological work. This Part I contains maps of fifty-six counties on forty-nine sheets. As this Journal has many times stated, the survey has gone forward with remarkable energy and thoroughness under its efficient and experienced head; and, owing to the varied resources of the State, has become more valuable as regards its economical results than that of any other State in the Union. It has also contributed largely to paleontology especially through its volumes on coal plants, and thrown light on many of the problems in American stratigraphical and dynamical geology. The anthracite survey is making good progress, and also the unfinished geological surveys of a few of the counties. The final report is in course of preparation by Professor Lesley and, when finished, will make the survey of largely increased value to the State through the systematic presentation of the facts and results now distributed with great detail in the several county reports. Pennsylvania surpasses all other States in its mineral wealth, and can therefore well afford to have prepared and published the most extensive of all geological and mineral State reports.

8. *Map of the Dominion of Canada geologically colored from surveys made by the geological corps,* 1842 to 1882. Geological and Natural History Survey of Canada, A. R. C. SELWYN, Director.—This fine map measures six feet across, and is a valuable contribution to American geological science. The survey has accomplished a great work in gathering the materials for so detailed a map.

9. *New Minerals from Colorado:* ZUNYITE, GUITERMANITE.—Dr. W. F. HILLEBRAND has recently described two new minerals from the Zuñi mine on Anvil Mountain, near Silverton, San Juan Co., Colorado. Zunyite occurs in very minute tetrahedral crystals showing the faces of both the plus and minus tetrahedrons, parallel to which there is easy cleavage, and frequently also those of the cube and perhaps the dodecahedron. The crystals are transparent, except for frequent black inclusions of titanic oxide, and have a glassy luster; the hardness is 7 and the specific gravity of the pure mineral 2·875. The mean of a number of partial analyses made upon material selected with all possible care is

SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	Li_2O	H_2O	P_2O_5	F	Cl
24·33	0·20	57·88	0·10	0·24	tr.	10·89	0·60	5·61	2·91=102·76

less O for F and Cl 3·02=99·74

In calculating the formula the Fe_2O_3 and P_2O_5 are neglected as due to impurity, and the water is assumed to be basic since it does not go off at 270° C. The atomic ratio for Si : (Al_2) : (H, K, Na) : (O, F_2, Cl_2)=0·4055 : 0·5674 : 1·2208 : 3·1232 or nearly 6 : 8 : 18 : 45, corresponding to $9R_2O$, $8Al_2O_3$, $6SiO_2$ with part of the oxygen replaced by fluorine and chlorine. The composition cannot be considered as definitely established as yet, and the very peculiar interest of the mineral makes it deserve further examination. The zunyite forms the gangue of an uncrystallized sulphide of lead and arsenic to which the name Guitermanite, after Mr. Franklin Guiterman, has been given. When fresh it is of a bluish-gray color, possesses a slight metallic luster, a hardness of about 3 and a specific gravity of 5·94. Analyses on two portions afforded:—

	S	As	Pb	Cu	Ag	Fe	Zunyite	
1. ⅔	19·67	13·40	63·60	0·17	0·02	0·43	1·77	=99·06
2. ⅔	19·56	13·00	61·63	0·17	0·02	0·88	3·82	O 0·55=99·63

Deducting a little lead sulphate, free sulphur and pyrite there remain S 17·68, As 13·00, Pb 59·85, Cu 0·17=90·70, which leads to the provisional formula $3As_2S_3$, 10PbS.

Another article by Dr. Hillebrand describes the occurrence and gives analyses of several interesting minerals from the American Eagle Mine, Tintic District, Utah, viz: *olivenite* in crystals, also in compact fibrous form; *conichalcite* in emerald-green globular forms with radiated structure; *chenevixite* in olive-green to greenish-yellow compact masses imbedded in the ore; also *jarosite* and a hydrous calcium arsenate in fine silky white needles. He also describes *bindheimite* from Secret Cañon, Nevada; *zinckenite* from the Brobdignag Mine, Red Mountain, San Juan County, Colorado; *melonite* from Boulder County, Colorado.

10. *On Colemanite, the new borate of lime.*—In the December number of this Journal, a preliminary notice was given by Professor A. Wendell Jackson of the crystalline form of the new borate of lime from Southern California, called Colemanite by Mr. J. T. Evans. Professor Jackson has now published an exhaustive monograph on the same subject in Bulletin No. 2 of the California Academy of Sciences, before which body his paper was read Oct. 6, 1884. His results show colemanite to be one of the most remarkable of minerals both in the beauty and perfection of the crystals, and the complexity of their forms. The crystals are generally clear and colorless with brilliant faces and vary for the most part from 5 or 6 mm. to 30 mm. in thickness. In some cases they line the cavities of large geodes in the massive mineral, forming most beautiful mineralogical specimens. Professor Jackson accepts the same axial ratio in his monograph as was given in the notice referred to, viz:

$$\grave{a} : \bar{b} : \dot{c} = 0{\cdot}774843 : 1 : 0{\cdot}540998 : \beta = 69^\circ\ 50'\ 45''.$$

He gives also a list of nearly forty planes which he has identified upon the crystals under examination. The crystals have a perfect cleavage parallel to the clinopinacoid and the habit varies from medium to short columnar, the unit prism ordinarily predominating; a striking feature is their resemblance in form to crystals of datolite. Professor Jackson's paper contains a long list of measured and calculated angles, the close agreement of which is an evidence of the perfection of the crystals. There are also four plates with a large number of figures, and a linear projection. It is not often that a new mineral species admits of so thorough a crystallographic examination. Prof. Jackson states that the locality from which the crystals examined came was Calico District, San Bernardino Co., California (not Death Valley, where, however, the mineral also occurs).

The chemical analyses by Mr. J. T. Evans have led to the formula $2CaO, 3B_2O_3+5H_2O$ or $Ca_2B_6O_{11}+5H_2O$; it is very near both priceite and pandermite (See Syst. Min., App. II, III), from the latter it differs in containing two molecules more water.

The same mineral has been studied by several other mineralogists, and their results confirm those of Professor Jackson, though made on a smaller selection of material; see vom Rath and Bodewig in the Verhandl. Nat. Verein d. preuss. Rheinl. u. Westf., pp. 333 to 342, and Hiortdahl, Zeitsch. für Kryst., x, 25. An analysis by Bodewig led to the same result as that given above; that of Hiortdahl varied somewhat, probably from want of purity in the material. Hiortdahl shows that the optic axes are in a plane normal to the clinopinacoid, the acute bisectrix lies in the obtuse axial angle and is inclined 26° 25′ (for Na) to the edge of the base and clinopinacoid; the interior angle of the optic axes $2V_a=55° 21'$, and the index of refraction $\beta=1·5876$.

11. *On Koninckite, a new hydrated phosphate of iron.*—M. Cesàro has recently described a new iron phosphate from Visé, Belgium, which he has named after Professor De Koninck of Liège. It occurs in small globular forms consisting of radiating needles, transparent and nearly colorless. Examined carefully these needles prove to have a single perfect cleavage and to belong to the monoclinic system. Its hardness is 3·5, and specific gravity 2·3. It fuses easily to a black bead. An analysis yielded the following results:

	P_2O_5	Fe_2O_3	Al_2O_3	H_2O
(⅔)	34·8	33·9	[4·5]	26·8=100

For this the formula $Fe_2O_3, P_2O_5+6H_2O$ is calculated. Koninckite occurs associated with richellite, a hydrous fluo-phosphate of iron recently described by the same author (see this Journal, xxvi, 411).—*Mem. Soc. Geol. Belgique*, xi, 247.

12. *Analysis of Titanic Iron Sand from Brazil;* by J. B. Mackintosh. (Communicated).—The mineral analyzed was given by Mr. John Gordon, Jr., of Rio Janeiro to Professor Egleston, at whose suggestion the present examination was made. It occurs

in river or beach sands, in small rounded grains, associated with monazite, garnet, tourmaline, quartz and mica. It does not dissolve sufficiently in hydrochloric acid to give the titanium reaction with tin. Its specific gravity is 4·2. An analysis afforded:

TiO_2	59·20
Fe_2O_3	32·11
FeO	4·9
MgO	1·73
SiO_2	1·16
	99·09

[illegible]

Omitting the silica which is present as a mechanical admixture, these figures lead to the provisional formula $3(Fe_2O_3, 3TiO_2) + 2(FeO, TiO_2)$. The oxygen ratio between protoxides, sesquioxides and titanic acid $= 1 : 4·5 : 11$, or for all the bases to titanic acid $= 1 : 2$. About 85 per cent then of the mineral is composed of the normal titanate of *sesquioxide* of iron, the other 15 per cent being normal titanate of the protoxide, which separates it widely from ordinary menaccanite.

13. *Mineralogical Notes;* by EDO CLAASSEN.—Mr. Claassen states that he has found ·08 per cent vanadic oxide and a trace of chromium oxide in the magnetite of Newboro, Canada; also ·028 per cent vanadic oxide, ·006 per cent chromium oxide and 5·27 per cent titanic oxide in the magnetite sand found on the shore of Lake Erie.

14. *Minerals from Middletown, Conn.*—In the note No. 9 on page 263, the closing lines of the first paragraph, relating to cerussite and pyromorphite, should be erased.

III. BOTANY AND ZOOLOGY.

1. *Origin of the Fauna and Flora of New Zealand.*—Captain F. W. HUTTON, of New Zealand, in articles published in the Annals and Magazine of Natural History, xiii, 425 (1884), and xv, 78 (1885), presents his views on the origin of the New Zealand fauna and flora. The earlier paper reaches the conclusion that, in the Lower Cretaceous, New Zealand formed part of a large South-Pacific continent extending from New Guinea to Chili, and so received species of plants and animals from Australia, Polynesia and South America; and also that in the Eocene another invasion of species from the same sources took place; but New Zealand in each remained an island, much larger than at present. In the later paper he considers the facts with reference to invasions of Antarctic and North-temperate species during the Pliocene. The following facts and views are from this paper.

New Zealand has, to the *eastward*, Chatham Isles (one volcanic peak of which is 600 feet high) 400 miles off, and the Antipodes Islands (700 feet in greatest height) 450 miles off; to the *southward*, the Aucklands (2000 feet high) 240 miles off, Campbell Island (1600 feet high) 420 miles off, and Macquarie Island, 600 miles distant from New Zealand.

As large a number of New Zealand living crustaceans exist in South America as in Australia, half as many antarctic flowering plants, the grasses excluded, and one-third as many of the grasses. Five of the New Zealand fresh-water fishes exist also in Australia and two in South America. Hence the conclusion that a former land-connection existed between these countries, as had been suggested by Sir J. Hooker, Mr. H. N. Moseley, and Mr. Wallace.

Tasmania and New Zealand, 600 to 900 miles apart, have 103 species of flowering plants (6·75 per cent) in common, but only two fresh-water fishes, and no fresh-water or land shells with one doubtful exception.

The elevation in the antarctic regions supposed to be thus indicated is referred to the Pliocene. With regard to the extent of New Zealand at the time the author observes that all the outlying islands are included within this land area by M. Blanchard; only Chatham Island, by M. A. Milne-Edwards; and probably all the area eastward to Chatham and south to Macquarie, by Wallace. At Chatham Islands the New Zealand species include 4 out of 21 land birds, and one of them, the gold cuckoo, is migratory to New Zealand and Australia; (on Pitt's Island) one lizard (*Mocoa Zelandica*), a slug (*Janella bitentaculata*), a land shell (*Thalassia Neozelanica*). There is one flightless rail (*Cabalus modestus*) on Pitt's Island, allied to *Ocydromus*, but nothing of *Apteryx*, *Stringops* or *Ocydromus*.

At the Aucklands are found a number of New Zealand land birds, three species of land shells and the slug *Janella bitentaculata.* Of the flowering plants of Auckland, Campbell and Macquarie Islands about 75 per cent occur on New Zealand. A connection of all these southern islands with New Zealand is hence probable. And as these islands contain antarctic species not occurring in New Zealand it is reasonable to conclude that the species reached New Zealand from the southward. Wallace makes the route for the Fuegian plants to have been through the South Shetlands from the Antarctic continent; and Sir J. Hooker makes Fuegia to be related more or less evidently in its plants with all the Antarctic islands, excepting those in the vicinity of New Zealand.

At the Kermadec Islands, 450 miles north of New Zealand, 14 per cent of the plants are endemic species; and the isolation of the group may therefore date from the same time.

Chatham Isles, the Aucklands and Campbell Island are related in their rocks to New Zealand, which are mainly non-volcanic. All the other antarctic islands are volcanic excepting South Georgia which has a mountain range of slate.

The author regards it as probable that an antarctic continent south of Africa, including Tristan d'Acunha and Kerguelen Island, existed from the Eocene to the Pliocene, but that a partial submergence separating off New Zealand occurred between the Eocene and Pliocene; and that Graham's Land, Enderby's Land and Victoria Land are some of the remnants of this land.

The succession of geographical changes was then as follows. Before the close of the Jurassic—as Jurassic and Triassic rocks, fossils, and coal beds show—New Zealand was the southern portion of a continental land extending through Australia to India, the Indo-oceanic continent of Mr. H. F. Blanford. After that a separation from Australia took place, and in the Upper Cretaceous New Zealand was smaller than now. But in the Eocene it spread out again, as above remarked, and plants and animals were received from the north and south; and again in the Pliocene, when immigration from the south took place. Then followed a sinking below the present level, to be elevated to its present level again during the Quaternary.

"But the more the geology and palæontology of large geographical regions, like North America or Europe, are studied, the more clearly we see that subterranean movements have affected large regions simultaneously, or nearly simultaneously, and that the local deviations from uniformity are comparatively small. So it comes about that we have in each large geographical area a series of rock systems which are nearly synchronous over the whole area, although not synchronous with those in other and distant areas. I think that our knowledge of the palæontology of Australasia is already sufficient to show that we have here also another of those large geographical areas which, when viewed on a large scale, has been moved uniformly; and therefore that the rock-systems of New Zealand can be correlated with those of Australia, and perhaps, in the earlier periods, with those of the peninsula of India."

* * * * * *

"Our fauna and flora is indeed a standing protest against the views of those naturalists who would make the winds scatter abroad insects and seeds of plants over hundreds of miles, and who imagine land-shells and lizards to float about on logs for days and weeks together without being killed."

With regard to the *Glacial era of the South Pacific*, Captain Hutton observes that it was not an era of unusual cold; that no glaciers ever reached the sea-level, although extending far beyond their existing limits; that there are no true erratics; that the land probably stood higher than now by perhaps 3,000 or 4,000 feet, and thence came the greater extension of the ice.

This era of the greater elevation of the land and of the large extension of the glaciers was, according to Captain Hutton (and "almost all New Zealand geologists"), earlier than that of the northern Glacial period, and probably coincident with the Pliocene elevation. One argument supporting this conclusion is the number of existing endemic species on the island. Again, marine beds, supposed to be Miocene—the "Pareora system"—containing 20 to 45 per cent of living species, are found along New Zealand from Southland to Auckland. They indicate a warmer climate than the present. Another later series is the "Wanganui system" containing 70 to 90 per cent of living species, and probably of newer Pliocene age. The era of elevation is placed between these two of depression. A later series, containing living species, and therefore Quaternary, occurs at many places on both islands.

The question as to glacial phenomena in Australia has been decided adversely by Mr. Tenison Woods and Mr. Howitt; but probable glacial striæ on Victoria are described by Mr. G. S. Griffiths, and farther north by Professor R. Tate. Marine Pliocene beds have been reported as occurring in Victoria up to 1720 feet above the sea.

IV. Miscellaneous Scientific Intelligence.

1. *Part II, Vol. VII of the Transactions of the Seismological Society of Japan.*—This volume, recently received, is mostly occupied by a paper from Professor John Milne, on three hundred and eighty-seven earthquakes observed during two years (Oct., 1881, to Sept., 1883) in North Japan. Besides a statement of the instruments used and the stations occupied, and a catalogue of the earthquakes, this gives one hundred and twenty-three maps of the areas affected by single earthquakes, one general map shaded to represent the distribution of volcanic and seismic activity in Japan, and sixty-six figures of the tracings made by the various recording instruments. Many of these latter are extremely curious and interesting, but must be *seen* to be appreciated. No description can do them justice. The earthquakes are tabulated with respect to their distribution in space and time and their relation to other natural phenomena. A few results reached may be briefly mentioned. He finds that eighty-four per cent of the earthquakes originated under the ocean or on the sea board; that the winter intensity is nearly three and a half times as great as the summer intensity; that there is a general coincidence between the maximum of earthquakes and the minimum of temperature and that there were 11·2 per cent more earthquakes at low water than at high water. Sixteen earthquakes occurred simultaneously in separated areas, not being felt in the intervening localities. He also finds that the indications of exactly similar instruments may vary considerably at stations only a few hundred feet apart, and hence concludes that the amplitude and period of the vibration constituting an earthquake is very largely dependent upon the character of the soil and other local circumstances. C. G. R.

2. *Proceedings of the Colorado Scientific Society*, vol. i, 147 pp., with a map. 1883–84.—The Colorado Scientific Society, the first meeting of which was held in January, 1883, has now published volume I of its Proceedings: it contains a number of valuable articles, one of which is noticed at length in another place. The volume closes with a list of the important minerals of Colorado. It is announced that the Society expects to issue one volume annually in future. The officers for 1885 are Presi-

dent Dr. W. F. Hillebrand, Vice-President Mr. P. H. van Diest, Secretary and Treasurer Mr. F. F. Chisolm.

3. *Report on the Waters of the Hudson River together with analysis of the same, made to the Water Commissioners of the City of Albany;* by C. F. CHANDLER, Ph.D., Jan., 1885.—In this paper the amount of soluble matters in different river waters is given as follows: in grains per gallon of 231 cubic inches and in parts per 10,000.

	Per gallon.	Per 10,000 parts.	Mineral matter.
Hudson River at Albany	4·665–7·581	8·00–13·00	4·50–9·80
Mohawk River	6·250	10·70	9·00

Of the amount, 1·50 to 5·00 in 10,000 are organic and volatile matters, deducting which leaves for the mineral matters in the Hudson River waters 4·50 to 9·80 inch in 10,000 parts as above stated, and for the mean amount 7·11. The average volume of the Hudson at Albany is given at 618,111 cubic feet per minute, equal to an average daily flow of 6,677,000,000 gallons. The investigation for this report had special reference to the purity of the waters for city supply.

4. *The life of James Clerk Maxwell, with selections from his correspondence and occasional writings;* by L. CAMPBELL, M.A., LL.D., Professor of Greek in the University of St. Andrews, and Wm. Garnett, M.A. New edition, abridged and revised, 422 pp. 12mo. London, 1884. (Macmillan & Co.).—This admirable biography of one of the greatest of physicists and mathematicians and best of men is an abridgment of the larger work published two years since.

OBITUARY.

JOHN GWYN JEFFREYS, the distinguished veteran conchologist, died suddenly on January 24th, at his residence in London. Mr. Jeffreys was born January 18, 1809, at Swansea, Wales. His earlier papers on conchology date back to 1828, and during the past fifty-six years he has been a constant contributor to the literature of his favorite branch of science. His most extensive work is the "British Conchology," in five volumes. He took a leading part in the earlier private dredging expeditions around the British coast, many of which were carried out in his yacht, the "Osprey," in 1861 to 1868. When the deep-sea dredgings were undertaken, with the aid of the English government, in 1868 to 1870, in the "Lightning" and "Porcupine," off the coasts of Great Britain and in the Mediterranean, he took an active part in those explorations. He also went in the "Valorous" to Baffin's Bay, in 1876, for the chance of doing some arctic deep-sea dredging. In 1871 he visited the United States and Canada for a short time, and while here made a brief visit to the U. S. Fish Commission, then in its first year of existence, and took part in a few short dredging trips in Vineyard Sound. In 1880 he went by invitation on the French dredging expedition of "Le Travailleur," in the Bay of Biscay. For several years past he has been engaged in publishing the conchological results of these various expeditions, and at the time of his death he was still actively engaged upon the shells of the Lightning and Porcupine expeditions. The greater part of these have already been published by him in the Proceedings of the Zoological Society, and probably the work on most of the remaining groups of Gastropoda was well advanced, if not completed, before his death.

To Mr. Jeffreys more than to any other conchologist science is indebted for the careful comparison of the European shells, both recent and fossil, of the numerous British and continental collections, and the consequent elimination of numerous nominal species and the disentanglement of their confused synonymy. He was especially interested in the geographical and geological distribution of European mollusca, and contributed very largely to a more correct and extended knowledge of these subjects.

Mr. Jeffreys had accumulated during a long and active life a very valuable and extensive collection of European shells, including a great number of types of his own species, as well as those of other writers. His entire collection was purchased by the U. S. National Museum two years ago, and a considerable part of it has already been received there. It should be a matter of congratulation to American naturalists that this unique collection will be preserved in this country and cared for in a manner commensurate with its scientific value. A. E. V.

SEARLES VALENTINE WOOD, JR., author of numerous valuable papers on British Geology—largely the Tertiary and Quaternary—died on the 14th of December last, in his fifty-fifth year. He was the son of the well-known paleontologist of the same name.

Elementary Text-book of Zoology, General Part and Special Part, Protozoa to Insecta. By Dr. C. Claus, Prof. Zool. and Comp. Anat. Univ. Vienna, Director Zool. Station at Trieste; translated and edited by Adam Sedgwick, M.A. Fellow and lecturer of Trinity College, Cambridge, with the assistance of F. G. Heathcote, B.A., Trinity College, Cambridge. 616 pp. 8vo, with 491 woodcuts. Part 2, Mollusca to Man, with 706 woodcuts. New York: 1885. (Macmillan & Co.)

Scientific papers and addresses by George Rolleston, M.D., F.R.S., Prof. Anat. and Physiology Oxford; arranged and edited by Wm. Turner, LL.D., F.R.S., Prof. Anat. Univ. Edinburgh, with a biographical sketch by Edward B. Tyler, D.C.L., F.R.S., Keeper of the Museum, Oxford. In two vols., 948 pp. 8vo, with portrait, plates and woodcuts. Oxford (Clarendon Press). New York (Macmillan & Co.)

Om Lydorganer hos Fiske. En physiologisk og comparativ-anatomisk Undersogelse, ved Wm. Sorensen, 246 pp. 8vo, with 4 plates. Copenhagen, 1884. (V. Thaning & Apels.)

Memoir upon the Formation of a Deaf Variety of the Human Race, by Alexander Graham Bell. Paper presented to the National Acad. Sci., Nov. 13, 1883, 86 pp. 4to.

Gleanings from outcrops of Silurian Strata in the Red River Valley, by J. Noyes Panton, M.A., paper read before the Manitoba Historical and Scientific Society, Winnipeg, Nov. 27, 1884.

Catalogue of Fossil Mammalia in the British Museum. Part I, containing the Orders Primates, Chiroptera, Insectivora, Carnivora and Rodentia; by Richard Lydekker, B.A., F.G.S., etc. London. 1885.—The British Museum "Catalogues" are largely descriptive, and on this account as well as the extent of the collections have great value.

The Prehistoric World or Vanished Races; by E. A. Allen, 820 pp. 8vo, with plates and cuts. Cincinnati, 1885. (Central Publishing House.)

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XLIV.—*Elasticity of Ice;* by JOHN TROWBRIDGE and AUSTIN L. MCRAE.

APPARENTLY the only previous experiments made to determine the modulus of elasticity of ice are those of Benjamin Bevan.* He went to a pond where the ice was about ten centimeters thick and sawed one end and two sides of a beam, leaving the other end attached to the main body of ice. He then loaded the free end and obtained the absolute modulus 54×10^9. Nothing is said about the ice returning to its first position when the load was removed, nor of the deflection due to the weight of the beam itself. As the weight of the beam was four or five times the heaviest weight used, this deflection would be quite appreciable. The lower surface of the ice apparently rested on the water of the pond which prevented it from deflecting as far as it would have done. The upward pressure of the water would in part counterbalance the effect of the weight of the beam.

Methods of Observation.

We first endeavored to obtain the modulus by a direct pull on a bar. For this purpose water was put in brass tubes closed at one end and boiled so as to expel bubbles of air, then frozen, sometimes artificially, but generally by placing the tubes out of the window and allowing the water to freeze naturally. The temperature of the air varying from −3° C. to −18° C. After it was thoroughly frozen, water from the water-pipes was allowed to flow over the tubes. This expanded the brass enough to allow the cylinder of ice to be slipped out without appreciable melting.

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* Phil. Trans., 1826.

Some of the cylinders looked homogeneous throughout, but most of them appeared to be very porous along their axes.

The bar was hung by a clamp at its upper end. At the lower end there was another clamp to which a scale pan was attached. A small fibre was fastened to the bar at the upper mark and terminated in a pointed plumb-bob. The fiber hung clear of the ice so that its length remained invariable and the yielding of the upper support made no difference. The increased difference in the readings of the plumb-bob and of the lower mark gave the elongation for a given weight. The increased length being so small and the least wind causing the fiber and bar to swing, the errors of observation were so large that this method was abandoned.

It may be interesting to note that a bar left suspended an entire day (temperature −13° C.) changed from a cylinder to a frustrum of a cone.

The next experiments were made to get the transverse vibrations of the ice. The bars were obtained in the same manner as in the previous method. A sewing needle frozen transversely to one end of the bar served as a pointer. The other end was firmly clamped. The clamp was cooled to zero before the ice was put in. A tuning fork was placed by the side of the ice and so arranged that the two pointers were on a line. The tuning fork and bar were then set in vibration and a piece of smoked glass drawn under the two pointers received the two curves. Knowing the rate of the tuning fork, the number of transverse vibrations of the ice was obtained by comparing the number in equal distances along the two curves.

We experienced great difficulty from the ice breaking when it was clamped or when it was struck to set it in vibration, but by continued trials we succeeded in obtaining two well-defined curves. The height of the vibrations was about one-third of a millimeter. It is not certain that the ice always attained its proper pitch.

The results are expressed in the following formula:

$$E = \frac{n^2 l^4 s}{(\cdot 28)^2 r^2}$$

in which l= length of the bar, r= the radius, s= specific gravity and n= the number of transverse vibrations per second.

Experiment I.—Jan. 29, 1885.

$l = 33\cdot$ cm. $r = \cdot 77$ cm. $s = \cdot 886$ $n = 54\cdot 15$

$\therefore$ $E = 66 \times 10^9$

Experiment II.—Jan. 31, 1885.

$l = 35\cdot$ cm $r = \cdot 90$ cm $s = \cdot 886$ $n = 51\cdot 4$

$\therefore E = 55 \times 10^9$.

Transverse Deflection.

We next went to a neighboring pond and sawed rectangular beams of ice and made measurements upon their elasticity at the pond. Two boards about 20 cm. wide and 60 cm. long were laid upon the ice. Two half cylinders of wood were placed upon these to form the supports for the beams. The cathetometer rested upon a board 30 cm. square placed upon the ice. It read to fiftieths of a millimeter. After the experiments the part of the scale used was compared with a standard centimeter, made by Prof. W. A. Rogers of the Harvard Observatory, and each millimeter was found to be not more than $\cdot 02^{mm}$ in error, so the readings were not corrected. A vertical rod with a needle at the top was inserted in a board 15 cm. square and served as an index. The index was placed on the middle of the beam and the weights were arranged symmetrically on each side.

The ice was 23 cm. thick, had no cracks or fissures and seemed to be free from air bubbles. There were about 3 cm. at the bottom which appeared to be of a later formation than the rest, it was therefore sawed off.

Care was taken to have all the apparatus below zero before the experiments began so as not to melt the ice. The wind was very light all day and did not shake the index. The results are given in tables I and II.

The difference in the modulus of the same bar with the same weight at different times may in part be due to slight variations in the positions of the weights. The index was simply placed on the beam and may have been jarred by putting on or taking off the weights, although as much care as possible was taken to avoid these errors. There did not seem to be a limit of perfect elasticity to any of the beams we used, but all gradually bent under their own weight. The readings were taken before, during and after the weights were on. The downward deflection is used in calculating E′ and the return deflection E.

The formula used was obtained in the following manner:

Let $P =$ weight divided in halves placed equidistant from the center of the beam, $a =$ distance between the weights, $l =$ length of span, $wl =$ weight of the beam. Take the origin at the centre of the curve. Then taking the moments about any section between one of the weights and the nearest support the elastic curve $E\frac{d^2y}{dx^2}=f(x)$ becomes

$$E\frac{d^2y}{dx^2}=-\left(\frac{P+wl}{2}\right)\left(\frac{l}{2}-x\right)+w\left(\frac{l}{2}-x\right)\left(\frac{\frac{l}{2}-x}{2}\right)$$

$$=-\frac{P}{2}\left(\frac{l}{2}-x\right)-\frac{w}{2}\left(\frac{l^2}{4}-x^2\right)$$

$$E\frac{dy}{dx}=-\frac{P}{2}\left(\frac{lx}{2}-\frac{x^2}{2}\right)-\frac{w}{2}\left(\frac{l^2x}{4}-\frac{x^3}{3}\right)+C$$

but $C=0$

$$Ey=-\frac{P}{2}\left(\frac{lx^2}{4}-\frac{x^3}{6}\right)-\frac{w}{2}\left(\frac{l^2x^2}{8}-\frac{x^4}{12}\right)+B$$

but $B=0$

limits $x=0,\ x=\frac{l}{2}$

$$Es=\frac{l^3}{4bd^3}(P+\tfrac{5}{8}W) \qquad \text{since } I=\frac{1}{12}bd^3$$

and $W=wl$.

s = the deflection at the centre if the weight was there.

limits $x=\frac{\alpha}{2}\quad x=\frac{l}{2}$

$$Es'=\frac{l^3}{4bd^3}(P+\tfrac{5}{8}W)-\frac{P}{4bd^3}\left(\frac{\alpha^2}{2}(3l-\alpha)\right)-\frac{w}{4bd^3}\left(\frac{\alpha^2}{8}(6l^2-\alpha^2)\right)$$

s' = the deflection at $x=\frac{\alpha}{2}$ when the weight is at the center.

The weight of the beam was acting all the time so that we only measured the deflection due to the weight P. Therefore the part containing W in the preceding formula will disappear. By the principle of reciprocal relations a weight at a distance from the centre $x=\frac{\alpha}{2}$ will produce the same deflection at the centre as the same weight placed at the center would produce at $x=\frac{\alpha}{2}$. If the weight had been at the centre we should have

$$E=\frac{Pl^3}{4bd^3s}$$

but we have seen that

$$s = \frac{s'l^3}{l^3 - \frac{\alpha^3}{2}(3l-\alpha)}$$

$$\therefore E = \frac{P}{4bd^3s'}\left(l^3 - \frac{\alpha^3}{2}(3l-\alpha).\right)$$

At another time we went where the old ice had been cut and a new crop about 5 cm. thick had formed. It was perfectly limpid and free from air bubbles. We sawed out half a dozen bars and conveyed them to the laboratory to make more careful measurements. The cathetometer rested on the stone steps of the laboratory. The same kind of supports was used as before. The index consisted of a needle run through a piece of cork which was pasted on the ice and could not be jarred. A similar index was placed upon the supports to see if they gave way under the load. It was found that they were firm and did not vary. All the apparatus was placed out in the air long enough to acquire its temperature before the experiments began.

The bars were smaller than the former ones and had a limit of perfect elasticity. In two cases the limit was exceeded, then smaller weights were put on and the bar was again perfectly elastic. The density of this ice was greater than that of the ice used in former experiments. It therefore appears that ice has a limit of perfect elasticity if small bars are used, but that large beams, although elastic to a certain extent, gradually bend under their own weight. The results are given in tables III and IV.

The symbols in the tables are:

L = length of the span,
T = temperature of the ice,
Δ = density of the ice,
b = breadth of the beam,
d = depth of the beam,
P = weight applied,
ϑ' = deflection of the beam from zero under a given load,
ϑ = the rise of the beam when the load is removed,
ε' = modulus of elasticity using ϑ',
ε = modulus of elasticity using ϑ,
α = distance between the weights.

The measurements are made in the C. G. S. system of units. The temperature is given in Centigrade degrees.

The values of ε and ε' are given in absolute measure.

I. FEBRUARY 12, 1885.

Bar.	L	a	T	Δ	b	d	P	ϑ'	ϑ	E	E′
A	118·	30	−10·0	·886	22·6	6·2	10,000	·016	·012	57×10^9	41×10^9

II. FEBRUARY 13, 1885.

Bar.	L	*a*	T	Δ	*b*	*d*	P	ϑ′	ϑ	E	E′
B	148	30	–3·0	·886	10·0	11·0	14,000	·0285	·014	56×10^{9}	26×10^{9}
C	205	"	"	"	10·0	8·7	6,000	·046	·035	53×10^{9}	41×10^{9}
"	"	"	"	"	"	"	"	·0404	·0302	62 "	46 "
"	"	"	"	"	"	"	8,000	·0495	·0423	59 "	50 "
"	"	"	"	"	"	"	10,000	·0704	·0494	63 "	44 "
"	"	"	"	"	"	"	12,000	·0705	·0535	70 "	53 "
"	"	"	"	"	"	"	10,000	·0708	·049	63 "	44 "
"	"	"	"	"	"	"	"	·055	·046	68 "	56 "
"	"	"	"	"	"	"	14,000	·085	·076	57 "	51 "
"	"	"	"	"	"	"	"	·100	·075	58 "	44 "
"	"	"	"	"	"	"	10,000	·054	·040	78 "	58 "
"	"	"	"	"	8·7	10·0	10,000	·049	·0344	68 "	48 "
"	"	"	"	"	"	"	14,000	·0568	·049	67 "	58 "
"	"	"	"	"	"	"	16.000	·0599	·0519	73 "	63 "
D	212	"	"	"	17·5	6·7	10,000	·155	·054	80 "	28 "
"	"	"	"	"	"	"	"	·0998	·0578	75 "	43 "
E	213	"	"	"	17·5	7·8	10,000	·100	·036	77 "	28 "
"	"	"	"	"	"	"	14,000	·121	·065	60 "	32 "
"	"	"	"	"	"	"	18,000	·155	·092	54 "	32 "
		"		Average			......	......	......	65×10^{9}	

III. FEBRUARY 19, 1885.

Bar.	L	*a*	T	Δ	*b*	*d*	P	ϑ′	ϑ	E	E′
H	107	20	–7·0	·920	4·5	6·6	4,000	·010	·010	88×10^{9}	88×10^{9}
"	"	"	"	"	"	"	6,000	·022	·022	60 "	60 "
"	"	"	"	"	"	"	10,000	·039	·039	57 "	57 "
"	"	"	"	"	"	"	16,000	·059	·059	60 "	60 "
"	"	"	"	"	"	"	25,459	·129	·069	81 "	44 "
"	"	"	"	"	6·6	4·5	10,000	·060	·060	79 "	79 "
"	"	"	"	"	"	"	25,459*	broke			"
I	94	"	"	"	6·6	4·5	22,730*	"			"
K	54	"	"	"	4·5	6·6	48,000*	"			"
				Average			....	......	......	71×10^{9}	

* Weight required to break the bar.

IV. FEBRUARY 20, 1885.

Bar.	L	*a*	T	Δ	*b*	*d*	P	ϑ′	ϑ	E	E′
M	131	20	–5·0	·920	5·0	6·8	10,000	·035	·035	97×10^{9}	97×10^{9}
"	"	"	"	"	"	"	"	·031	·031	109 "	109 "
"	"	"	"	"	"	"	14,000	·059	·059	80 "	80 "
"	"	"	"	"	"	"	24,543	·135	·088	95 "	62 "
"	"	"	"	"	"	"	25,000*	broke			
N	"	"	"	"	6·8	5·0	10,000	·090	·058	108×10^{9}	70×10^{9}
"	"	"	"	"	"	"	4,000	·028	·028	90 "	90 "
				Average						96 "	

* Weight required to break the bar.

Longitudinal Vibrations.

Before using bar M table IV we compared its note with that of a pitch pipe which had been graduated by a siren.

The ice gave three-tenths of a semitone of C sharp.

American Pitch.

Pitch Pipe C,	67·93	135·9	271·7	543·5	1087
C#,	71·97	143·9	287·9	575·8	1152

ε = modulus of elasticity,
n = number of longitudinal vibrations per second,
l = length of bar,
Δ = density of bar,
$n = 1107. \quad l = 138. \quad \Delta = \cdot920.$
$\therefore \varepsilon = 4l^2n^2\Delta = 86 \times 10^9.$

Summation.

Average of table I - - - - - -	57	× 10^9
" " " II - - - - - -	65	"
" " " III - - - - - -	71	"
" " " IV - - - - - -	96	"
" " all the observations - - - -	72	"

We assign greater value to tables III and IV than to I and II:

Average of tables III and IV - - -	84	× 10^9
" " transverse vibrations - -	61	"
" " longitudinal " - - -	86	"

Velocity of Sound in Ice.

$$v=\sqrt{\frac{\varepsilon}{\Delta}}=\sqrt{\frac{84\times10^9}{\cdot920}}=290{,}000\text{ cm. per sec.}=2900\text{ m. per sec.}$$

or about nine times the velocity of sound in air.

Jefferson Physical Laboratory.

Art. XLV.—*Contributions from the Agricultural Experiment Station of the University of Wisconsin. Digestion Experiments;* by H. P. Armsby.

The methods of cattle-feeding worked out by the scientific experiments of the last twenty years require, as their basis, a knowledge of the average composition and digestibility of the fodders in common use. Thanks to the labors of American experiment stations, we have now a very fair knowledge of the composition of American feeding-stuffs; but for all estimates of their digestibility we have been obliged to take the results of experiments on fodders grown in foreign countries, no determinations of the digestibility of any of our fodders having been reported. The following determinations of the digestibility of clover hay, malt-sprouts and cotton-seed meal by sheep are therefore presented as a contribution to our knowledge of the digestibility of American fodders:

Fodders.—The hay was first-crop red clover hay, of good quality, and nearly free from admixture of other vegetation. The malt-sprouts and cotton-seed meal were also of excellent quality, as was evident from their appearance and was confirmed by the results of chemical analysis.

Conduct of experiments.—Two grade Cotswold wethers, about three years old and weighing about 87 pounds each, were used for the experiments. The animals stood in stanchions, each in a separate stall specially built for the purpose. They were fed from zinc-lined feed boxes, which could be removed to be filled, and which were surmounted by a funnel-shaped structure of boards, which effectually prevented any scattering of the fodder. Each day's fodder was weighed out separately for from six to ten days in advance, the hay in cloth bags, the bye-fodder in glass fruit jars, and samples were taken at the same time for the determination of moisture or for complete analysis. The dung was collected in rubber-lined cloth bags (*Kothbeutel*), attached to the hind quarters of the animals by means of a light harness. The bags were emptied every twenty-four hours and the dung weighed.

A sample of about 100 grams of the fresh dung of each animal was at once taken and dried in a water bath. When sufficiently dry, it was allowed to stand loosely covered for about twelve hours, then weighed, rapidly ground, and preserved in a tightly closed glass jar. The percentage of water in the air-dry dung was subsequently determined, thus affording data for calculating the daily excretion of dry matter by each animal on every day of the experiments. At the close of each period, the samples of air-dry dung were mixed to form an analysis sample in such proportions that the quantity of dry matter from each day's dung contained in the mixture was proportional to the amount of dry matter excreted by the animal in question on that day.

As is well known, it is necessary in digestion trials to precede the actual experiment by a preliminary feeding in order to remove from the digestive organs remnants of previous fodder. In these experiments the preliminary feeding and the actual trial each lasted six days, in most cases. Throughout the experiments two grams of air-dry salt per day and head were given.

Sampling.—Since the value of a digestion experiment is largely dependent upon the correct sampling of fodders and dung, particular attention was paid to this point.

Each day's dung was sampled by spreading it out in a shallow tray and taking small portions from different parts of the tray until the desired amount was obtained.

The malt-sprouts and cotton-seed meal were sampled at the time of weighing out for feeding. The amount required for the last four days of the preliminary feeding and the six days of the actual experiment was weighed out at one time, each day's feed separately. As each one of these twenty portions was weighed out, a small amount was laid aside, and the mixture of these small portions constituted the analysis sample.

Substantially the same method of sampling was applied to the hay, but as it was desired to ascertain by these trials the average composition and digestibility of a considerable quantity of hay, the process was somewhat more elaborate.

The clover hay, to the amount of about three and one-half tons, was run through a power feed cutter, using nominally a half inch cut, although most of the hay was not actually cut as fine as that. The cut hay was spread out on a tight floor and thoroughly mixed, being handled entirely with shovels to prevent, as far as possible, the sifting to the bottom of the finer portions. It was then spread out about two feet deep in an approximately rectangular form upon a tight floor. Beginning near the diagonally opposite corners, two trenches, each about a foot wide, were dug into the mass parallel to the longest side of the rectangle, care being taken to secure whatever dust had sifted through to the floor. (Very little dust was found.) Two samples of about 500 pounds each were thus secured and stored separately in bins, and a digestion experiment was made with each sample.

In weighing out the hay for the experiments, a quantity more than sufficient was spread out upon a tight floor and cloth bags were filled by taking about two shovelfuls each, from different parts of the mass, while at the same time an analysis sample was taken in the way above described for the other fodders.

In the experiments with hay alone the fodder for the preliminary feeding and the actual experiment was weighed out at different times, so that we have two analyses of each of the 500 pound samples mentioned above. In the subjoined table these are numbered 1, 2, 3 and 4, and their close agreement attests the accuracy of the sampling.

Composition of Fodders.—Water Free.

No.		Ash.	Albuminoids.	"Amides."	Crude Fiber.	N. free Extract.	Fat.
1	Clover Hay	5·11	13·49		32·34	47·19	1·87
2	Clover Hay	4·99	10·71	2·31	32·99	47·24	1·76
3	Clover Hay	4·59	13·73		32·24	47·32	2·12
4	Clover Hay	4·85	10·71	2·90	32·88	46·89	1 77
5	Malt Sprouts	4·26	16·40	7·46	13·63	56·79	1·46
10	Cotton-seed Meal	7·01	43·01	4·60	3·00	27·83	14·55

Analytical Methods.—Water was determined by drying two grams at 110° C. in a current of dried illuminating gas, ash by burning at a low temperature and deducting CO_2 and char, fat by extraction of the dry substance with dry sulphuric ether, crude-fiber substantially by the modified Weende method of Wattenberg.[*] Total nitrogen was determined by combustion with the mixture of slaked lime and sodium carbonate recommended by Johnson and Jenkins.[†] Protein signifies nitrogen ×6·25. "Amides" (more properly non-albuminoid nitrogenous matters) were determined by Stutzer's method,[‡] the soluble nitrogen found by that method being multiplied by 6·25. Albuminoids equal protein minus "amides." Nitrogen-free extract is by difference.

PERIOD I.

During the first period, each sheep received per day in two feeds 700 grams of hay from one of the 500 pound samples previously mentioned, with water *ad libitum* twice per day. This amount of hay was eaten clean. The analyses above show the composition of the hay used for the preliminary feeding (No. 1) and the actual experiment (No. 2). As weighed out it contained:

No. 1,	83·87	per cent. of dry matter.
No. 2,	83·59	" " "

The water-free dung had the following composition:

	Ash.	Protein.	Crude Fiber.	Nitrogen-free extract.	Fat.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Sheep 1	6·71	14·38	35·19	41·38	2·72
Sheep 2	6·57	14·00	35·31	41·51	2·23

The weights of fresh dung and of dry matter excreted, and of water drunk were as follows:

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[*] Jour. f. Landw., xxviii, 273.
[†] Am. Chem. Jour., i, 77.
[‡] Jour. f. Landw., xxviii, 103, and xxix, 473.

	Sheep 1.			Sheep 2.		
	Fresh dung. Grms.	Water-free dung. Grms.	Water drunk. Grms.	Fresh dung. Grms.	Water-free dung. Grms.	Water drunk. Grms.
Nov. 11	611·4	284·4	?	548·7	247·4	?
" 12	613·3	283·3	0	575·4	265·6	0
" 13	683·2	317·8	865	609·0	280·0	1630
" 14	555·7	263·2	893	622·6	[226·4]	1077
" 15	630·5	303·5	312	849·5	367·2	298
" 16	569·3	276·6	0	636.3	269·0	198
Average	610·6	288·1	414	640·3	285·8†	641
Correction*		0·5			0·5	
		288·6			286·3	

* For dung adhering to bags. † Excluding Nov. 14th.

In the following table are calculated from these data the average amount of each ingredient of the hay eaten, excreted and digested per day:

	Dry matter. Grms.	Organic matter. Grms.	Protein. Grms.	Albu-minoids. Grms.	Crude fiber. Grms.	Nitrogen-free extr't. Grms.	Fat. Grms.
Sheep 1.							
Fed, 700 grms. hay	586·1	556·6	77·7	62·8	191·5	276·7	10·7
Excreted, 610·6 grms. dung	288·6	269·2	40·4	40·4	101·5	119·4	7·9
Digested	297·5	287·4	37·3	22·4	90·0	157·3	2·8
Per cent digested	**50·8**	**51·6**	**48·0**	**35·7**	**47·1**	**56·8**	**26·2**
Sheep 2.							
Fed, 700 grms. hay	586·1	556·6	77·7	62.8	191·5	276·7	10·7
Excreted, 640·3 grms. dung	286·3	267·5	41·2	41·2	101·1	118·8	6·4
Digested	299·8	289·1	36·5	21·6	90.4	157·9	4·3
Per cent digested	**51·1**	**51·9**	**47·0**	**34·4**	**47·2**	**57·1**	**40·2**

In these computations the average of analyses 1 and 2 is assumed to represent the composition of the hay. The "Amides," being soluble in water, are assumed to be wholly digestible.

PERIOD II.

In the second period, Sheep 1 received 700 grams and Sheep 2 but 650 grams of hay, each in two feeds per day, from the second of the two 500 pound samples. (Analyses No. 3 and No. 4.) Here follow the further data for this period.

Dry matter of hay.

No. 3,	84·59 per cent.
No. 4,	84·13 "

Composition of Dung.—Water free.

	Ash.	Protein. (Nx6·25)	Crude Fiber.	Nitrogen free extract.	Fat.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Sheep 1	6·71	13·99	35·70	41·24	2·36
Sheep 2	6·47	14·04	35·65	41·68	2·16

Daily Excretion.

	Sheep 1.			Sheep 2.		
	Fresh dung.	Water-free dung.	Water drunk.	Fresh dung.	Water-free dung.	Water drunk.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Nov. 23 ..	607·9	294·2	695	508·6	244·0	978
" 25 ..	651·8	300·8	921	589·8	279·0	595
" 26 ..	618·6	283·2	113	529·3	245·4	14
" 27 ..	554·1	253·0	0	480·8	234·4	0
" 28 ..	639·1	301·3	680	565·7	266·7	1474
Average .	614·3	286·5	483	534·8	253·9	612
Correction		0·5			0·5	
		287·0			254·4	

Digestibility.

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extr't.	Fat.
Sheep 1.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Fed, 700 grms. hay	591·2	563·3	80·8	63·3	192·5	278·5	11.5
Excreted, 614·3 grms. dung	287·0	267·7	40·2	40·2	102·4	118·3	6·8
Digested	304·2	295·6	40·6	23·1	90·1	160·2	4·7
Per cent digested	**51·5**	**52·5**	**50·2**	**36·5**	**46·8**	**57·5**	**40·9**
Sheep 2.							
Fed, 650 grms. hay	549·0	523·1	75·0	58·8	178·8	258·6	10·7
Excreted, 534·8 grms. dung	254·4	237·9	35·7	35·7	90·7	106·0	5·5
Digested	294·6	285·2	39·3	23·1	88·1	152·6	5·2
Per cent digested	**53·7**	**54·5**	**52·4**	**39·3**	**49·3**	**59·0**	**48·6**

As in period I, the average of the two analyses of the hay is made the basis of the computation.

In the following table are brought together for more convenient comparison the results of periods I and II.

Percentage Digestibility of Clover Hay.

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.
Sheep 1.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Period I	50·8	51·6	48·0	35·7	47·1	56·8	26·2
Period II	51·5	52·5	50·2	36·5	46·8	57·5	40·9
Average	51·2	52·1	49·1	36·1	47·0	57·2	40·9*
Sheep 2.							
Period I	51·1	51·9	47·0	34·4	47·2	57·1	40·2
Period II	53·7	54·5	52·4	39·3	49·3	59·0	48·6
Average	52·4	53·2	49·7	36·9	48·3	58·1	44·4
Average of all	51·8	52·7	49·4	36·5	47·7	57·7	42·7*

* Excluding the result on sheep 1 in period I as probably erroneous.

PERIOD III.

In a third period, the digestibility of malt sprouts was the subject of experiment, the sprouts being fed with the clover hay already experimented upon. Unfortunately, Sheep No. 2 had to be excluded from this experiment on account of a sore foot in consequence of which he ate poorly. Sheep No. 1 received per day 600 grams of the clover hay and 175 grams of malt sprouts. The latter were soaked in hot water and fed while still warm, the whole amount, together with half the hay, being fed at night and the remainder of the hay in the morning.

The preliminary feeding in this period was continued for nine days, but the analysis samples represent the material fed during the last four days of the preliminary feeding and the six days of the actual experiment.

In this and the subsequent period the average of analyses 1, 2, 3 and 4 is taken to represent the composition of the dry matter of the hay. Its digestibility is assumed to be the average of that found in Periods I and II for the animal under consideration.

Dry matter of Fodders.

Hay (No. 6),	83·49 per cent.
Malt Sprouts, (No. 5),	88·03 "

Composition of Dung.—Water free.

	Ash. Per cent.	Protein. Per cent.	Crude fiber. Per cent.	Nitrogen-free extract. Per cent.	Fat. Per cent.
Sheep 1	6·28	14·07	34·09	43·70	1·86

Daily Excretion.

	Sheep 1.		
	Fresh dung. Grms.	Water-free dung. Grms.	Water drunk. Grms.
Dec. 10	604·0	276·6	1120
" 11	802·5	356·5	624
" 12	732·9	298·6	0
" 13	626·8	281·1	1332
" 14	697·8	288·7	85
" 15	622·6	266·5	354
Average	681·1	294·7	586
Correction		0·5	
		295·2	

Digestibility.

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extr't.	Fat.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Fed, 600 grms. hay	500·9	476·4	67·4	53·6	163·3	236·3	9·4
Fed, 175 grms. malt sprouts	154·1	147·5	36·8	25·3	21·0	87·5	2·2
Total	655·0	623·9	104·2	78·9	184·3	323·8	11·6
Excreted, 681·1 grms. dung	295·2	276·6	41·5	41·5	100·6	129·0	5·5
Digested, total	359·8	347·3	62·7	37·4	83·7	194·8	6·1
Digested from hay	256·4	248·2	33·2	19·4	76·8	135·2	3·8
Digested from malt sprouts	103·4	99·1	29·5	18·0	6·9	59·6	2·3
Per cent digested	**67·1**	**67·2**	**80·2**	**71·2**	**32·9**	**68·1**	**104·6**

Period IV.

The preliminary feeding continued six days. Each animal received 700 grams of hay and 175 grams of cotton-seed meal. The meal was given dry, sprinkled over the night feed of hay, and the fodder was always eaten clean. For sixteen days previous to the preliminary feeding the sheep had been fed the same fodders, and in approximately the same amounts, as in the experiment. The analysis samples of the fodders represent, as in Period III, the last four days of the preliminary feeding and the six days of the actual experiment.

Dry matter of fodders.

Hay (No. 9),	84·09 per cent.
Cotton-seed meal (No. 10.),	92·41 "

Composition of Dung.—Water free.

	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Fat.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Sheep 1	6·44	15·31	34·57	41·87	1·81
Sheep 2	6·35	15·72	33·98	42·15	1·80

Daily Excretion.

	Sheep 1.			Sheep 2.		
	Fresh dung.	Water-free dung.	Water drunk.	Fresh dung.	Water-free dung.	Water drunk.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
January 8	740·7	297·0	1417	894·1	369·7	765
" 9	1010·1	392·8	751	750·5	307·0	113
" 10	805·2	298·0	1176	759·7	295·6	1588
" 11	792·4	292·6	1119	707·1	283·5	1375
" 12	852·3	342·0	397	921·5	348·7	411
" 13	686·8	273·9	1106	699·6	264·1	978
Average		316·1	994		311·4	872
Correction		0·5			0·5	
		316·6			311·9	

Digestibility.

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.
Sheep 1.	Grms	Grms	Grms	Grms	Grms	Grms	Grms
Fed, 700 grms. hay	588·6	559 8	79·2	63·0	191·9	277·6	11·1
Fed, 175 grms. cotton-seed meal	161·7	150·4	77·0	69·5	4·9	45·0	23·5
Fed, total	750·3	710·2	156·2	132·5	196·8	322·6	34·6
Excreted, 814·6 grms. dung	316·6	296·2	48·5	48·5	109·4	132·6	5·7
Digested, total	433·7	414·0	107·7	84·0	87·4	190·0	28 9
Digested from hay	301·4	291·7	39·0	22·7	90·2	158·8	4·5
Digested from cotten-seed meal	132·3	122·3	68·7	61 3	?	31·2	24·4
Per cent digested	**81·8**	**81·3**	**89·2**	**88·2**	?	**69.3**	**103·9**
Sheep 2.							
Fed, total	750·3	710·2	156·2	132·5	196·8	322·6	34·6
Excreted, 788·8 grms. dung	311·9	292·1	49·0	49·0	106·0	131·5	5·6
Digested, total	438·4	418·1	107 2	83·5	90·8	191·1	29·0
Digested from hay	308·4	297·8	39·4	22·9	92·7	161·3	4·9
Digested from cotton-seed meal	130·0	120·3	67·8	60·6	?	29·8	24·1
Per cent. digested	**80·4**	**80·0**	**88·1**	**87·2**	?	**66·2**	**102·5**

It is of some interest to compare these results with those obtained by Wolff in some recent experiments,* also on sheep:

Digestibility of Cotton Seed Meal.

	Wolff's experiment.	Average of these experiments.
Dry matter	74·0	81·1
Organic matter	80·4	80·7
Protein	84·7	88·7
Crude fiber	----	----
Nitrogen-free extract	83·7	67·8
Fat	87·6	----

In the following table the amounts of digestible matters present in the three fodders have been calculated in per cents of the whole fodder:

	PERCENTAGE COMPOSITION.							DIGESTIBLE.			
	Water.	Ash.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.	Protein. (N×6·25).	Albuminoids.	Carbhydrates.†	Fat.
Clover hay, average of four analyses	16·07	4·10	11·30	8·99	27·37	39·58	1·58	5·58	3·27	35·80	0·67
Malt sprouts	11·97	3·75	21·00	14·44	11·99	50·00	1·29	16·86	10·27	38·35	1·29
Cotton-seed meal	7·59	6·48	44·00	39·59	2·77	25·72	13·44	39·07	34·72	17·67	13·44

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* Landwirthschaftliche Versuchs-Stationen, xxvii, 215.

† Digestible crude fiber and nitrogen-free extract.

PROBABLE ERRORS OF THE RESULTS.

It is a matter of some importance to know to what amount of error the results obtained in these experiments are subject. They obviously are not susceptible to a strict mathematical treatment according to the theory of probabilities, such as might be applied to astronomical or physical observations. At the same time it appears possible, by making what seem reasonable assumptions upon certain points, to fairly approximate to the probable errors of the results. In the following paragraphs this has been attempted:

Experiments with hay alone.—a. Errors in weighing fodder and dung. The hay was weighed out upon a balance sensitive to 0·1 gram. As, however, the conditions were not always favorable to extreme care in weighing we will assume 0·1 gram as the probable error of a single weighing. Then, since the weight of the hay was obtained by subtracting the weight of the empty from that of the filled bag, the probable error in the weight of hay for one day is $\pm\sqrt{0{\cdot}1^2+0{\cdot}1^2}=\pm0{\cdot}14$ grms. In like manner, the weight of fresh dung daily excreted is subject to a probable error of ± 0·14 grams. As, however, the experiment was continued for six days, the probable error of the *average for one day* is in each case $\pm\ 0{\cdot}14 \div \sqrt{6} = 0{\cdot}058$ grams. This quantity, expressed as per centage of the average amount fed or excreted (700 grams and 622 grams), equals 0·008 per cent and 0·009 per cent respectively, and is obviously so small that for the purposes of this calculation it may be neglected.

b. Analytical errors. In addition to the errors arising in the weighing of fodder and dung, the unavoidable errors of analysis must be taken into account. These can be computed with some degree of accuracy for the determinations of dry matter, nitrogen and crude fiber. For the organic matter and fat the data are less complete, and owing to the less importance which attaches to these determinations, the computations have not been attempted. Nitrogen-free extract has also been excluded from the computation, because, being determined by difference, all the errors of the other determinations are included in it.

The amount of dry matter fed in Periods I and II is deduced from the average of analyses Nos. 1 and 2 and Nos. 3 and 4 respectively, or, each determination being in duplicate, from the average of four single analyses.

Taking this small number as the basis of a calculation of probable error we obtain the following results:

PERIOD I.

		v.	vv.
	83·86 per cent.	+0·125	0·0156
	83·89 "	+0·155	0·0240
	83·60 "	−0·135	0·0182
	83·59 "	−0·145	0·0210
Sum,	334·94	0	0·0789
Average,	83·735 "		

Probable error of one determination 0·110 per cent.

PERIOD II.

	84·65 per cent.	+0·2925	0·085556
	84·52 "	+0·1625	0·026406
	84·13 "	−0 2275	0·051756
	84·13 "	−0·2275	0·051756
Sum,	337·43	0	0·215475
Average,	84·3575 "		

Probable error of one determination 0·186 per cent.

Subsequently, twelve determinations of dry matter were made upon another fodder (coarse wheat bran) by the same method.

These twelve determinations gave as the probable error of a single determination of dry matter by this method ± 0·12 per cent, a result agreeing well with the smaller of the two errors computed above.

If, then, in our computations, we assume ± 0·12 per cent to represent the probable error of one determination of dry matter, we shall at least not over-estimate it.

For a computation of the probable error of the nitrogen and crude fiber estimations in the fodder we have eight determinations each, made on samples agreeing so closely in composition that they may fairly be assumed to have been identical. On this assumption, we get the following results:

Nitrogen.			Crude fiber.		
	v.	vv.		v.	vv
2·10	−0·05	0·0025	32·92	−0·65	0·4225
2·20	+0·05	0·0025	32·95	−0·62	0·3844
2·07	−0·08	0·0064	33·55	−0·02	0·0004
2·09	−0·06	0·0036	33·64	+0·07	0·0049
2·21	+0 06	0·0036	33·71	+0·14	0·0196
2·19	+0·04	0·0016	33·44	−0·13	0·0169
2·21	+0·06	0·0036	33·96	+0.39	0·1521
2·13	−0·02	0·0004	34·36	+0·79	0·6241
17·20	0	0·0242	268·56	0	1·6249
2·15			33·57		

Probable error of 1 determination ±0·040.

Probable error of 1 determination ±0·325.

Twelve determinations each of nitrogen and crude fiber on the sample of bran mentioned above gave the following results:

	Nitrogen.	Crude fiber.
Probable error of 1 determination...	0·052 per cent.	0·22 per cent.

These figures differ somewhat, but not very greatly, from those computed directly from the analyses in question, and serve to show that the latter include no gross errors.

The determinations of dry matter, protein and crude fiber in the dung were made in precisely the same manner as with the fodders. As only duplicate determinations were made on any one sample there are no sufficient data for a computation of probable errors, but there is no evident reason why they should differ essentially from those of the same determinations on fodders, and we shall assume that they do not.

From these data as to the probable errors of the percentages of dry matter, protein and crude fiber found by analysis, we proceed to compute, in grams, the probable errors of the amounts of each ingredient eaten and excreted. In doing this it must be remembered that the percentages of dry matter are to be calculated upon the amount of air-dry hay fed, or of fresh dung excreted, while the percentages of protein and crude fiber are to be reckoned upon the amount of *dry matter* fed, or excreted. We may, for convenience, first compute the probable errors on the basis of a single determination each to be as follows:

Probable Errors.—Single Determination.

	Average consumption. Grms.	Average excretion. Grms.
Fresh	700	622
Dry matter..	588 ± 0·84	287 ± 0·75
Protein (N × 6·25)	78 ± 1·47	39 ± 0·72
Crude fiber	189 ± 1·91	99 ± 0·93

These probable errors have now to be reduced in accordance with the number of observations upon which the value of each quantity depends. These are as follows:

For dry matter, protein and crude fiber of fodder, four determinations; for protein and crude fiber of dung, two determinations. The value for dry matter excreted rests upon duplicate daily determinations, repeated for six days. The error as above computed, then, should be divided by $\sqrt{2}\times\sqrt{6}=3{\cdot}46$.

For the actual probable errors, then, we find the following amounts:

Probable Errors.

	Average consumption. Grms.	Average excretion. Grms.	Average digested. Grms.
Dry matter	588 ± 0·42	287 ± 0·22	301 ± 0·47
Protein (N × 6·25) ...	78 ± 0·74	39 ± 0·51	39 ± 0·90
Crude fiber.........	189 ± 0·96	99 ± 0·66	90 ± 1·17

By dividing the probable errors of the last column by the amounts of the corresponding ingredients fed, we obtain the percentage error, viz:

Dry matter	±0·08 per cent.
Protein	±1·15 "
Crude fiber	±0·62 "

That is, the percentages for digestibility as given on p. 360 are subject to these errors.

Experiments with bye-fodders.—In these experiments we have the additional errors arising in the weighing out and analysis of the bye-fodder.

a. Errors in weighing. The bye-fodders were weighed on the same balance as the hay, but were weighed directly, and are consequently subject to an error of only ± 0·1 gram for a single weighing. Both bye-fodders and hay were weighed out for ten days at a time instead of for six as in Periods I and II. Plainly, then, the error due to weighing will be less than in those periods and may be neglected.

b. Analytical errors. The analytical errors we may calculate upon the same basis as before, remembering, however, that the composition of the hay in these experiments is the average of eight determinations, except the dry matter, which is the average of but two (compare p. 358), while that of the bye-fodder is the average of only two.

The errors in the determination of the excretion would be practically the same in amount as before.

PROBABLE ERRORS.

Malt Sprouts.

	Dry matter. Grms.	Protein (N×6·25). Grms.	Crude fiber. Grms.
Hay fed	500±0·51	67±0·44	163±0·57
Malt sprouts fed	154±0·15	37±0·27	21±0·35
Total fed	654±	104±	184±
Excreted	295±0·22	42±0·51	101±0·66
Digested	359±0·97	62±	83±
Digested from hay	256±0·40	33±0·76	76±1·08
Digested from M. S.	103±0·70	29±1·05	7±1·43
Percentage error	±0·45 pr. ct.	±2·84 pr. ct.	±6·82 pr. ct.

Cotton-seed Meal.

	Dry matter. Grms.	Protein (N×6·25). Grms.	Crude fiber. Grms.
Hay fed	589±0·59	79±0·52	192±0·68
C. S. M. fed	162±0·15	77±0·29	5±0·37
Total fed	751±	156±	197±
Excreted	314±0·22	49±0·51	109±0·66
Total digested	437±	107±	88±
Digested from hay	301±0·47	39±0·90	90±1·17
Digested from C. S. M.	136±0·80	68±1·19	−2±1·55
Percentage error	±0·49 pr. ct.	±1·55 pr. ct.	±31·01 pr. ct.

It thus appears that the digestion coëfficients for the bye-fodders are subject to a considerable analytical error, which, when expressed as above, of course varies in amount with the proportion of the ingredients in question which the bye-fodder contains. Thus the absolute probable error of the amount of crude fiber digested is very nearly the same in the malt sprouts as in the cotton-seed meal, but the very small percentage of fiber contained in the latter substance renders the percentage error much greater.

There is, however, another and more serious source of error in the determination of the digestibility of bye-fodders. G. Kühn* has recently shown that the digestibility of the same fodder by the same animal may vary at different times. He shows this to be true for hay alone, and also for a mixture of hay and bran. In these experiments the same phenomenon appears. Sheep No. 2 digested the hay decidedly better in Period II than in Period I, (compare p. 360), the differences being much larger than the probable errors of experiment, while Sheep No. 1 shows no such difference except as regards the protein and perhaps the fat. The variations of the single coëfficients from the mean of the two periods is:

Dry matter	1·3 per cent.
Protein	2·7 "
Crude fiber	1·1 "

There is no obvious reason why the digestibility of the hay may not have varied from the mean assumed for it in the experiments with bye-fodders. We have no measure of the probable amount of that variation, but it is reasonable to assume a *possible* variation at least as great as that observed on the hay alone. Then in the calculations on p. 363 the values of the amounts digested from the hay will be subject to a possible error from this cause of

	Malt sprout experiments.	C. S. M. experiments.
Dry matter	± 6·50 grms.	± 7·64 grms.
Protein	± 1·81 "	± 2·13 "
Crude fiber	± 1·79 "	± 2·11 "

Combining these with the probable analytical errors, we have the following for the *possible* errors. (We omit the calculation for the sake of brevity.)

Possible Errors.

	Malt sprouts.		Cotton-seed meal.	
	±		±	
Dry matter	6·54 grms.	= 4·25 per cent.	7·67 grms.	= 4·74 per cent.
Protein	2·09 "	= 5·66 "	2·44 "	= 3·17 "
Crude fiber	2·29 "	= 10·91 "	2·62 "	= 52·37 "

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* Landw. Versuchs-Stationen, xxix, 1.

In view of these large possible errors, it is quite evident that the determinations of the digestibility of these three ingredients of the malt-sprouts and cotton-seed meal have little scientific value. This was, of course, sufficiently evident as regards the crude-fiber of the cotton-seed meal from the fact that an apparent negative digestibility was observed. Moreover, it is evident that the fat determinations are equally valueless, since an apparent digestibility of more than 100 per cent was observed in every case. We must conclude, then, that while, as shown on p. 366, the digestibility of the total ration was determined with reasonable accuracy, the computation of the digestibility of the bye-fodder involves so many possibilities of error that the results have very little value. Essentially the same conclusion was reached by Kühn in his paper already cited.

If we concede this, however, the further question arises, whether the results of the large number of digestion experiments made upon bye-fodders during the past twenty years deserve any greater degree of confidence. So far as the writer can see, this question must be answered in the negative. Both Kühn's experiments and those here reported were made with every precaution to ensure accuracy, and, so far as can be judged from the published accounts, are at least equal in this respect to the great majority of other experiments. Moreover, it has been assumed that there was no error of sampling and no loss of either fodder or excrement. In short the computed possible errors are due simply to errors of analysis and possible variations of digestibility and these we have endeavored not to over-estimate. The averages of a number of determinations which we find given in tables of the digestibility of fodders, have, of course, a certain practical value as approximations to the truth. They may properly be made the basis of the calculation of rations in practice, but neither they nor the single results upon any given fodder can properly enter into any scientific calculation of the nutritive effect of a ration.

ART. XLVI.—*Massive Safflorite;* by LEROY W. MCCAY.

ABOUT a year and a half ago I published, in Freiberg, Saxony, a pamphlet upon cobalt, nickel and iron pyrites.* In the first part of this little brochure I endeavored to show that the rhombic modification of speiskobalt, so carefully described by Sandberger and by him called spathiopyrite, is identical with the safflorite of Breithaupt. The arguments advanced in support of the identity of the two minerals proved amply convincing, for, shortly after the appearance of the pamphlet, Sandberger, in a letter to the editors of the Jahrbuch,* distinctly admits his willingness to withdraw his name spathiopyrite and to substitute for the same the Breithaupt term safflorite.

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* Beitrag zur Kenntniss der Kobalt, Nickel- und Eisenkiese, Freiberg, 1883.

In my article upon safflorite, however, I not only concluded, in accordance with Breithaupt's, Sandberger's and my own researches, that there was actually a *crystalline* rhombic modification of speiskobalt, but also that there was undoubtedly a *massive* rhombic modification of this species. Sandberger, now, although ready to admit the existence of the crystalline modification, i. e. safflorite, calls in question my right to use the term to cover the massive varieties. Why he should object to my using the words in the broad sense I am unable to discover. He further appears to doubt the accuracy of the statement which appears so often in Breithaupt's Paragenesis,† to the effect that speiskobalt and safflorite appear together, and suggests it as well to examine the specimens belonging to the Freiberg collection with the view of discovering what this safflorite really is. The specimens from Bieber, Schneeberg, Reinerzau and Wittichen which Sandberger had opportunity to examine exhibited no indications of the two minerals occurring together.

It is just possible that Sandberger may have misunderstood me respecting my reasons for inferring the existence of massive safflorite, and yet I am unable to see why, for, with one possible exception, my language on this point is perfectly clear. It is not intended that the word safflorite shall be used to designate *all* massive varieties of speiskobalt, as Sandberger seems to infer, but only to specify such as possess as high a gravity as 7·0. It is a well established fact that numbers of specimens of massive speiskobalt give specific gravities ranging from 6·9–7·3, that these specimens are invariably gray and that they are, as a general thing, rich in iron. The specific gravity of typical smaltine is now about 6·50, consequently these arsenides cannot be real smaltine, and, since the iron cannot occasion the high weight, there remains but one species under which to class them and this species is safflorite. We have a massive variety of the rhombic modification of the nickel arsenide and its high specific gravity is its exclusive determining mark; hence, nickel and cobalt being twin elements, the right of insisting upon the exisence of the corresponding cobalt compound is certainly just and proper. If the existence of the massive variety of safflorite be deemed questionable, then the existence of the massive variety of rammelsbergite must be deemed questionable, for the proof in favor of the existence of the former is fully as convincing as that in favor of the existence of the latter. I feel sure that the majority of mineralogists will support me upon this point. Before it was fully settled that there was a rhombic modification of speiskobalt it was perfectly proper to question the propriety of regarding these heavy varieties as other than tesseral in system, but now that the existence of safflorite has been established on an incontrovertible basis no doubt can, I think, be raised as to the right of classing them under the rhombic form. Thus our classification would be complete for, just as we have with reference to nickel:

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* Neues Jahrbuch für Min., Geol. und Palæont., Jahrgang, 1884, vol. i, pp. 69–70.

† Die Paragenesis der Mineralien, pp. 222, 223.

I.	Chloanthite, tess., sp. gr.	6·50
II.	Rammelsbergite, rhomb., sp. gr.	7·122
	1. crystalline.	
	2. massive.	

So likewise have we with reference to cobalt:

I.	Smaltine, tess., sp. gr.	6·50
II.	Safflorite, rhomb., sp. gr.	7·129
	1. crystalline.	
	2. massive.	

So much then for my reasons for insisting upon the existence of the massive variety.

While engaged in studying cobalt and nickel minerals I did not examine a massive variety of safflorite and my conclusions were all drawn from analyses made by others. After reading Sandberger's letter I wrote to Professor Weisbach in Freiberg, requesting him to send me for examination some specimens of speiskobalt which should, if possible, exhibit the occurrence of smaltine and massive safflorite together. Professor Weisbach, with his usual courtesy and amiability, responded immediately to my request, and forwarded to me several pieces of a massive, gray and very heavy specimen of cobalt arsenide. Upon two of these pieces there are perched a number of little tin-white crystals of smaltine perfectly distinct and well marked. The Schneeberg miners call the gray mineral schlackenkobalt and as such it was labeled.

The fracture is conchoidal, the structure proper finely granular and microcrystalline. Here and there little cavities are visible lined with microcrystals. The surfaces exhibit a faint shimmer and some pieces show a play of colors. In addition to the smaltine already mentioned there is present a small quantity of crystallized quartz.

The specific gravity was first taken with a number of pieces about the size of peas, no special care, however, being observed as to selection. I obtained:

1.	6·832
2.	6·839
3.	6·845

Although too high for smaltine the results were unsatisfactory. A careful examination, with a hand glass, of a large number of pieces, disclosed the presence of numerous tiny orifices. I therefore selected with the greatest care a sufficient quantity of what appeared to be the most homogeneous chips, and again made two determinations. I obtained:

1.	6·858
2.	6·859

In every case the pieces of mineral were thoroughly boiled in water.

These figures are also too low. All five, however, agree in a very remarkable manner with the specific gravity of a crystalline safflorite which was analyzed by Jaeckel* in Heintz's laboratory. The specific weight was taken by Rose, who found 6·840. Rose says the weight is low owing to the presence of porosities. Feeling assured that these porosities were the cause of the trouble in my case, I powdered a quantity of the schlackenkobalt, brought 5·2555 grams into a picnometer and, having filled the same about half full of water, placed it for one hour under the air pump, then for two hours on the boiling water bath and, finally, heated the water in the bottle over a free flame to boiling, care being taken to avoid any loss which might result from too violent ebullition. The heating was continued for several minutes. After the water had cooled to the temperature of the room the specific gravity of the mineral was again taken. In this case the result was most satisfactory, the figure 7·167 being obtained. Temperature of the water during the experiment 25·5° C. The mineral, then, is either rammelsbergite or safflorite. I next made a very careful chemical analysis with the following result:

Quantity for analysis 0·5 grm.

As	69·52
S	0·90
Co	18·36
Ni	not even a trace!
Fe	9·40
Cu	0·62
Bi	tr.
Insoluble	1·30
	100·10

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* Rose's Krystallo-chemisches System.

The arsenic was estimated according to a method of my own which is fully described in the Chemical News, vol. xlviii, No. 1232, page 7. The cobalt was determined electrolytically.

After subtracting the insoluble residue, recalculating and dividing each percentage by the proper atomic weight we obtain:

As	70·36	÷	75	=	0·938	
S	0·90	÷	32	=	0·028	
Co	18·58	÷	59	=	0.314	·492
Ni						
Fe	9·51	÷	56	=	0·169	
Cu	0·62	÷	63	=	0·009	
Bi	tr.					
	99·97					

To form RS^2 14 atoms of R are necessary. Subtracting this amount from 492 we obtain:

$$478 : 938 = 1 : 1{\cdot}96$$
$$= 1 : 2$$

Hence the formula is:

$$\left.\begin{array}{l} x\,(RS^2) \\ X(RAs^2) \end{array}\right\} R=\text{Co, Fe and Cu.}$$

My analysis of schlackenkobalt agrees in a most peculiar way with the analysis of a mineral from Schneeberg which was examined by Von Kobell* and called by him eisenkobaltkies. In order that a comparison can be readily made, I here place the two analyses along side of each other:

Von Kobell (Schneeberg). Sp. gr.=6·95 Crystallized.		McCay (Schneeberg). Sp. gr.=7·167 Massive.	
As	71·08	As	70·36
S	tr.	S	0.90
Fe	18·48	Co	18·58
Co	9·44	Fe	9.51
Ni	none	Ni	none
Cu	tr.	Cu	0·62
Bi	1·00	Bi	tr.
	100·00		99·97

It will be seen that the quantity of cobalt in the schlackenkobalt is identical with the amount of iron in the eisenkobaltkies and that the quantity of cobalt in the eisenkobaltkies is identical with the amount of iron in the schlackenkobalt. This is certainly most remarkable! Can it be the result of chance? I think not; I am inclined to believe that Von Kobell made a mistake in writing down his figures—that he confounded the cobalt with the iron percentage and vice versa. The sum 100 indicates that the analysis was done by difference. Had it been made directly and had the sulphur and copper been carefully determined the chances are the agreement with my results would have been even closer.

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* Von Kobell: Gründ. Min., 1838, S. 300.

It is a very interesting fact that the mineral analyzed by Von Kobell was crystalline. He says it was between tin-white and light steel-gray in color, and he calls attention to the fact the crystals were grouped in spheres and resembled, individually, thin, flat rhombohedrons. The mineral will be immediately recognized as Breithaupt's safflorite. It is exceedingly gratifying to find an analysis of a crystalline safflorite which agrees so well (although, I must confess, in a peculiar way) with one of the massive variety and the meaning is at once evident.

The specific gravity 7·167, together with the results of the chemical analysis, prove without a doubt that the heavy, gray and massive mineral sent me by Professor Weisbach and labeled schlackenkobalt is, indeed, safflorite, and the accompanying tin-white smaltine demonstrates conclusively that smaltine and safflorite do appear together and that too in precisely the manner indicated by Breithaupt in his Paragenesis. I trust, then, that this article will serve to overthrow any doubt which may exist in the minds of mineralogists concerning the certainty of the existence of a massive variety of safflorite and that my views as here set forth may atone for any equivocal statement or statements which may have inadvertently crept into my pamphlet.

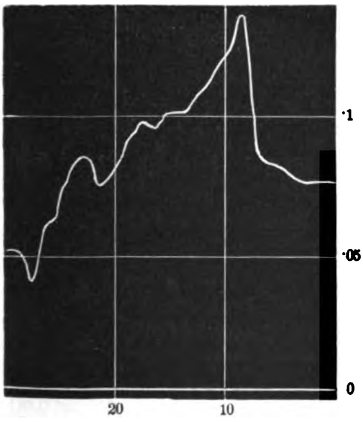
John C. Green School of Science, Princeton, N. J., Jan. 20th, 1885.

ART. XLVII.—*Application of Photography to Electrical Measurements;* by JOHN TROWBRIDGE and HAMMOND VINTON HAYES.

IN the study of electromotive force and of voltaic cells it is often desirable to have long continued observations. The complete history of the action, for instance, of the Daniell cell with different strengths of solution extending over hours or days, if it could be presented to the eye as a curve, would be valuable to those who desire to know the behavior of such a cell while it is doing work under definite conditions. Such curve could be obtained by patient observation, but it would be unprofitable labor for one to spend his time in watching the excursions of a galvanometer needle, if the needle can be made to record its movements by any device.

The method we have used enables one to study the action of a cell at one's leisure, the apparatus running at night or during the day when one is occupied with other work. A beam of light from a gas flame passes through a vertical slit placed in front of the flame and is reflected from the concave mirror of a tangent galvanometer, of few turns of wire, through a horizontal slit in a dark box in which a sheet of sensitive paper is placed. By means of this arrangement of a vertical and a horizontal slit a small point of light is obtained. A stationary concave mirror is placed near the needle of the tangent galvanometer, so that the same beam of light may be reflected by both this mirror and the one attached to the galvanometer needle. The spot of light given by the stationary mirror serves to mark the zero point of the needle when no current is passing through the galvanometer. The photographic paper is placed in a slide which is lowered uniformly by the unwinding of a string from a little cylinder placed either upon the hour hand or the minute hand of a cheap eight-day clock. When the electrical current from the voltaic combination, which is being used, passes through the galvanometer its changes in strength for different times are indicated by the relations of the two lines drawn upon the sensitive paper. The line drawn by the light from the stationary mirror is a straight one, and serves for the abscissa of times, while the perpendicular distances from the curve drawn by the mirror attached to the needle of the galvanometer to this axis of times give the ordinates of the curve drawn by the latter. Rapid printing paper was used and an ordinary gas flame gave a sufficiently strong spot of light to produce an actinic effect.

1.



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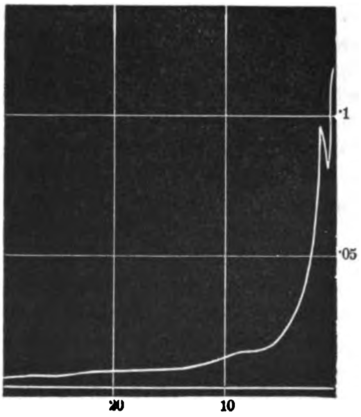


Fig. 1 represents the action of a modification of Trouvé's battery. During this experiment, which lasted for thirty minutes there were five ohms in the external circuit. The right hand portion of the diagram shows the strength of current when the circuit was made, and it will be observed that the battery was not at its best until ten or twelve minutes after making the circuit; from this maximum point the strength of the current gradually diminishes. Fig. 2 shows the action of the same battery with ten ohms external resistance. Under these conditions we find at the instant of making circuit a strong current which rapidly diminishes within the first five minutes to one-sixth of its first strength.

Knowing the distance of the galvanometer from the sensitive paper the strength of the current may be calculated by measuring the distance between the two lines at any instant and proceeding as with an ordinary galvanometer and scale.

From a comparison of the two figures the electromotive force may be determined by Ohm's law, if the distance between the lines is measured at the instant the current is made. Then knowing the electromotive force, current, and external resistance, we can readily find the internal resistance. This resistance will be the liquid resistance of the cell only for the moment that the circuit is made, for afterward the variation in electromotive force due to polarization, and the change in resistance of the liquid due to electrolytic action will combine to cause changes. Since, however, the changes in electromotive force due to polarization are much more rapid in their action than the changes in battery resistance a very small error will be introduced if we compare points near each other on those parts of the curve in which the variation in current is greatest: during the small fraction of a minute that is taken the change in battery resistance will be infinitesimal and may be neglected.

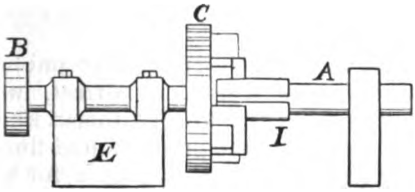
We have selected these photographs as an example of the large variations that some batteries present and the consequent usefulness of some such way of studying their action. From measurements upon these photographic charts the variations in electromotive force and internal resistance can be studied by obtaining such charts under different conditions of external resistance. It is evident that the same photographic method can be employed to study the swing of the needle of a short coil galvanometer which indicates the gradual heating of a thermopile. In this way the conduction of heat along a bar could be studied.

Jefferson Physical Laboratory.

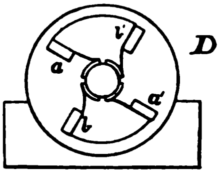
ART. XLVIII.—*On the production of alternating currents by means of a direct current dynamo-electric machine;* by JOHN TROWBRIDGE and HAMMOND VINTON HAYES.

IT is often desirable to transform a direct current into an alternating one for the purpose of obtaining electricity of high tension by means of a Ruhmkorff coil, for studying the effects of stratifications in vacuum tubes, or for employing alternating currents in the study of magnetism. The best way is undoubtedly to employ an alternating dynamo-electric machine, as has been done by Spottiswoode. When, however, only a direct current machine is available the following method can be employed:

1.



2.



The dynamo machine, if it is not a shunt wound machine, is shunted by a suitable resistance. We have employed for this purpose thin ribbon steel about 1·5 cm. broad and ·01 mm. in thickness. The remaining portion of the current from the machine is conducted to two brass or copper segments *a a′*, fig. 2. This current is led to the primary coil for, for instance of a Ruhmkorff coil from two other segments *b*, *b′*. These segments are fixed upon a cylindrical shaft A, fig. 1, which is stationary. A belt passing over the pulley B turns the wheel C upon the face D of which revolve four brushes which connect the adjoining segments. The brushes *a a*, *b b*, are made adjustable, the two adjoining brushes being electrically connected, and a small stream of water plays upon the segments of the commutator. The character of the spark produced by a Ruhmkorff coil which is marked by alternating currents has been studied by Spottiswoode. Without condensers in the secondary circuit a bright yellow glow spans the distance between the two terminals of the coil which partakes more of the character of a voltaic arc than of the ordinary discharge from a Ruhmkorff coil. The apparatus which we used produced three thousand reversals a minute. This rate was too rapid for the best effects with a Ruhmkorff coil. It enabled us, however, to study the musical note produced in the cores of the electro-magnet by rapid reversals of the current in the electro-magnet, and also the heating effects which have been so often studied.

Jefferson Physical Laboratory.

ART. XLIX. — *Topaz from Stoneham, Maine;* by F. W. CLARKE and J. S. DILLER.[*]

IN 1882, Mr. G. F. Kunz called attention to a new locality for topaz, discovered by Mr. N. H. Perry, of South Paris, Maine, in the neighboring town of Stoneham. The announcement aroused considerable interest among collectors of minerals, and somewhat later the locality became famous as a source of the very rare species herderite. In addition to topaz and herderite, the locality yields albite, apatite, autunite, biotite, beryl, columbite, damourite, fluorite, gahnite, garnet, muscovite, orthoclase, quartz, triplite, and zircon, together with other materials of obscure and doubtful character. This list of species was furnished by Mr. Perry, who also supplied us with material for investigation.

In the latter part of 1883, Mr. C. M. Bradbury[†] published an analysis of the Stoneham topaz, which, if correct, would show the mineral to be quite unlike any topaz hitherto known. His results were as follows, and make the proportion of fluorine half as high again as the generally accepted formula for topaz would require. The figures in parentheses are added to facilitate comparison with our own data:

Sp. Gr. 3·54

Al	27·14	(Al_2O_3, 51·26)
Si	14·64	(SiO_2, 21·37)
F	29·21	
O	28·56	
	99·55	

The peculiar interest attaching to these figures made a new analysis desirable; and accordingly the task was undertaken in the laboratory of the U. S. Geological Survey. Meanwhile Mr. Perry had called our attention to some apparently altered topaz; the crystals of which, having the unchanged mineral at the centre, were transformed upon the surface to a dark purple, soft substance, easily cut with a knife. Between the purple zone and the topaz was a greenish, intermediate layer, which shaded off imperceptibly into the original nucleus.

Intimately associated with the topaz, in all the specimens received by us, was a mineral identified by Dr. T. M. Chatard as damourite. This mineral occurs at the locality in two forms; first, as a broadly foliated mica, much like a pale green muscovite, and sometimes very well crystallized; and secondly, as a massive, subfibrous, dark green variety, suggestive of steatite or serpentine. Both forms were analyzed by Dr. Chatard,* and the analyses have already been published:—they are reproduced here for comparison in series with those of the topaz and its alterations. The latter were analyzed by Mr. Edward Whitfield, who examined the topaz itself, the greenish intermediate layer, and the outermost purple product. The topaz was white, massive, and somewhat milky, and the method of analysis was, as in the case of Bradbury's work, the old zinc oxide process of Berzelius. The alkalies were estimated with the aid of the bismuth oxide method of decomposition, as proposed by Hempel, and modified in this laboratory by Chatard.† The results may be tabulated as follows:

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[*] The microscopic and crystallographic work described in this paper is entirely due to Mr. Diller.—F. W. C.

[†] Chemical News, xlviii, 109.

A, unaltered topaz; B, greenish layer; C, purple zone; D, massive damourite; E, foliated damourite.

	A.		*B.*		*C.*		*D.*	*E.*
Sp. Gr.	3·51		3·42		2·82		-------	-------
Hardness	8.		7.		3.		-------	-------
SiO_2	31·92	-----	35·15	-----	44·52	-----	45·19	45·34
Al_2O_3	57·38	-----	53·18	-----	46·19	-----	33·32	33·96
F	16·99	17·21	12·88	-----	0·40	0·38	-------	-------
H_2O	0.20	0·20	0·90	0.90	3·74	3·99	4·48	4·78
K_2O	0·15	0·12	1·52	-----	2·30	-----	11·06	10·73
Na_2O	1·33	1·18	1·28	-----	2·82	-----	1·57	1·49
FeO	------	-----	------	-----	------	-----	4·25	3·96
MnO	------	-----	------	-----	0·21	-----	0·58	0·51
CaO	------	-----	1·32	1·42	0·30	0·48	trace.	0·22
MgO	------	-----	0·17	0·14	0·14	-----	0·36	0·10
	107·97		106·40		100·62		100·81	101·09
Deduct oxygen	7·16		5·42		·16			
	100·81		100·98		100·46			

If we now consider these analyses in their order, we find first that the topaz itself is ordinary topaz, having none of the anomalous character indicated by Mr. Bradbury's work. The small quantities of alkalies present may be attributed either to admixed impurity, or to an incipient alteration such as is suggested by analyses B and C. The latter point clearly to a progressive change from topaz towards damourite, the fluorine and some alumina having been gradually eliminated and replaced by other constituents. This change was probably brought about by the action of potash solutions, produced by the kaolinization of adjacent feldspathic material, the removal of fluorine and alumina having been followed by the taking up of potassium. One preliminary experiment, bearing upon this mode of alteration, has been tried. A weighed quantity of the topaz, in fine powder, from the sample which was analyzed by Mr. Whitfield, was digested on the water bath for seven days with a weak solution of potassium carbonate. Then, after filtering, the amount of fluorine in the filtrate was estimated, and found to be 0·38 per cent. of the weight of topaz taken. That is, fluorine can be slowly extracted from topaz by the suggested process, although further experiments are needed to make the case anything like complete.

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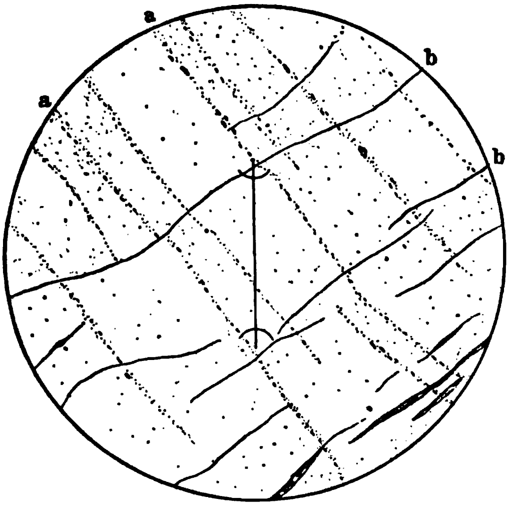
* This Journal, July, 1884. Also Bulletin No. 9, U. S. G. S.

† Bulletin No. 9, U. S. G. S., 1884.

Inasmuch as the chemical analyses alone do not prove completely the change from topaz to damourite, microscopic slides were made and examined, using the specimen which showed the alterations most perfectly. In this specimen the purple zone had a thickness of about one centimeter, and exhibited on its surface the crystalline faces of topaz. On other altered specimens even the topaz striæ were distinctly visible. By means of the well-marked basal cleavage it was easy to determine and prepare particular sections parallel and perpendicular to the vertical axis, and both sections extended from the outside of the purple border into the fresh topaz. In the basal section the position of the brachypinacoidal plane was readily determined by means of the plane of the optic axes, which is represented by the vertical line in the middle of fig. 1.

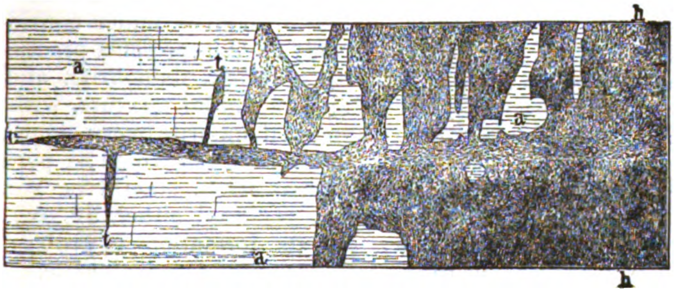
1.



Basal section of a Topaz Crystal.

In the topaz there are many liquid inclusions (*a*, *a*, fig. 1) from which the bubble readily disappears upon heating; and these are usually arranged in planes extending in nearly the same direction as, and approximately parallel to the most common prismatic planes *I* and $i\text{-}\breve{2}$. Almost at right angles to these, as represented in fig. 1, are numerous fissures, (*b*, *b*); which lie for the most part near the same prismatic planes. The fissures represented in the lower right-hand portion (*c*) of the figure are filled with a finely foliated, micaceous mineral, whose physical and optical properties, as far as they can be observed, agree fully with those of the damourite which was subjected to analysis by Dr. Chatard. The foliæ of damourite occur in fissures only; and although considerably interwoven, they are for the most part nearly parallel to the fissures in which they lie. The same fissures (*t*, *t*) are seen in a vertical position in fig. 2, which represents a section perpendicular to that shown in fig. 1; i. e., parallel to the vertical axis of the topaz. In fig. 2 the basal cleavage of the topaz is plainly seen (*a*, *a*); and nearly parallel with it are prominent cross-fractures, one of which is represented near the middle of the section (*c*). The damourite extends far into the topaz along these basal fractures in the form of veins, and from the latter it sends off tongues into the prismatic fissures. These, as shown in the figure, gradually increase in size from left to right, until the topaz entirely disappears, and the whole mass is made up of scales of damourite. The position of each scale bears no definite relation whatever to the crystallographic axes of the topaz; although the foliæ are generally parallel, they are often irregularly interwoven. The fact, as shown in fig. 2, that between the mass of the topaz and the damourite, there is an intermediate zone in which both are intermingled, is exceedingly important. Furthermore, the damourite always occurs in

Fig. 2.



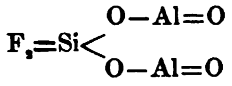
Vertical section.

fractures belonging to the topaz; indicating clearly that the fracturees were formed before the damourite, and determined its position. The basal fissures of the topaz, which depend upon its basal cleavage, once extended directly through the place now occupied by damourite, showing that the same space was once filled by topaz, and that the former must be an alteration product of the latter.

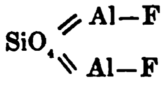
It will at once be seen that the crystallographic and microscopic evidence is even more emphatic than the chemical analyses in pointing to the conclusion that the altered topaz is essentially damourite. And yet, if we compare the analysis of the purple material with the typical damourite examined by Chatard, we find that the transformation is chemically not quite perfect. More alumina must be lost and more potassium must be gained before the alteration can be considered completely damouritic; or, in other words, certain stages of the chemical process, although easily to be understood, are yet to be actually observed on specimens of minerals. The state of the case, as it stands in the actual specimens under consideration, is probably as follows: Analysis A represents practically unaltered topaz; B, a mixture of topaz, damourite, and an intermediate alteration product; C, a similar mixture, with the topaz almost wholly removed and the damourite overwhelmingly predominating. The intermediate product, which is perhaps microscopically identical with topaz itself, should be simply the latter species with its fluorine replaced either by oxygen, by hydroxyl, or by both; and its formation is probably a necessary antecedent to the production of the damourite. The loss of fluorine appears to have preceded the taking up of alkalies.

In order to make clear the relations between topaz and damourite, we may profitably consider a few structural formulæ. Reduced to its simplest empirical expression, the composition of typical topaz corresponds to the formula $Al_2F_2SiO_4$. This may be written structurally in seven different ways; three being as follows, and the others variations of these:

1.



2.



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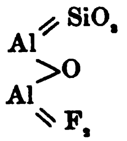
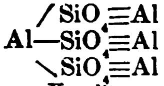


The first formula is rather improbable, the second represents an orthosilicate, the third falls under a metasilicate type. Which one is best supported by evidence?

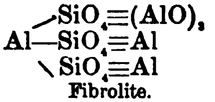
A prime difficulty in the way of discussing the chemical structure of minerals arises from the fact that we have as yet no trustworthy means of ascertaining their true molecular weights. The formula of topaz, for example, may either be the simple expression given above, or a multiple of that; and our only method of even approximately solving the problem is to study the reactions of topaz, or, in other words, its modes of alteration. Now the simplest formula for pure damourite, and one which is commonly recognized, is $Al_3KH_2(SiO_4)_3$. That is, damourite is far more readily and probably figured as an orthosilicate than in any other way; and this fact tends to sustain the orthosilicate formula for topaz.

Inasmuch as the formula of damourite contains three SiO_4 groups, we may now triple the simplest formula for topaz, and write in probable structural fashion the formulæ of the two minerals side by side. The results will be suggestive, even standing by themselves; but more so if we consider at the same time a number of other allied species. These are xenolite, fibrolite, paragonite, and eucryptite. Xenolite, which is optically identical with fibrolite, has been reëstablished as a distinct mineral by the analysis of Wiik; fibrolite is unquestionably related to topaz; paragonite is the sodium analogue of damourite, and eucryptite is especially noteworthy for its alterability into hydro-mica. Tripling the formulæ commonly assigned to fibrolite and eucryptite, the series may be presented as follows:



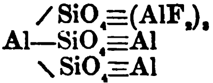
$$\begin{array}{l} \quad\diagup SiO_4\equiv Al \\ Al-SiO_4\equiv Al \\ \quad\diagdown SiO_4\equiv Al \end{array}$$

Xenolite.



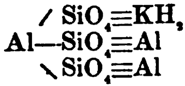
$$\begin{array}{l} \quad\diagup SiO_4\equiv (AlO)_3 \\ Al-SiO_4\equiv Al \\ \quad\diagdown SiO_4\equiv Al \end{array}$$

Fibrolite.



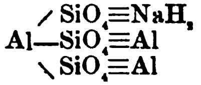
$$\begin{array}{l} \quad\diagup SiO_4\equiv (AlF_2)_3 \\ Al-SiO_4\equiv Al \\ \quad\diagdown SiO_4\equiv Al \end{array}$$

Topaz.



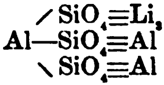
$$\begin{array}{l} \quad\diagup SiO_4\equiv KH_2 \\ Al-SiO_4\equiv Al \\ \quad\diagdown SiO_4\equiv Al \end{array}$$

Damourite.



$$\begin{array}{l} \quad\diagup SiO_4\equiv NaH_2 \\ Al-SiO_4\equiv Al \\ \quad\diagdown SiO_4\equiv Al \end{array}$$

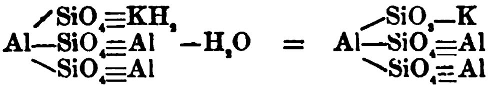
Paragonite.



$$\begin{array}{l} \quad\diagup SiO_4\equiv Li_3 \\ Al-SiO_4\equiv Al \\ \quad\diagdown SiO_4\equiv Al \end{array}$$

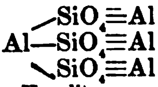
Eucryptite.

Xenolite, it will be observed, is the normal orthosilicate of aluminum, and from it, by a simple process of substitution, the others may be directly developed. In a future paper an effort will be made by one of us to show that the formulæ of all orthosilicates containing aluminum may be similarly derived, in such a way as to bring out most clearly and unmistakably the relations of the mineral species to each other. The system is particularly applicable, with great definiteness, to the orthosilicate micas, and even shows the derivation of metasilicates from them; as in one case which may be fairly presented here. If we simply withdraw from damourite the elements of water, a mixed ortho- and metasilicate will be formed,—thus:

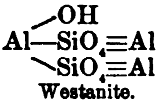


$$\begin{array}{l} \quad\diagup SiO_4\equiv KH_2 \\ Al-SiO_4\equiv Al \\ \quad\diagdown SiO_4\equiv Al \end{array} - H_2O \;=\; \begin{array}{l} \quad\diagup SiO_3-K \\ Al-SiO_4\equiv Al \\ \quad\diagdown SiO_4\equiv Al \end{array}$$

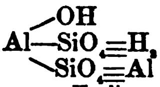
Two other derivatives of this group of compounds may be cited for example of an extension of this process, namely, westanite (or wœrthite, a hydrous fibrolite) and kaolin. If half of the water in the latter mineral be regarded as water of crystallization, the formula of kaolin will become that of xenolite with an aluminum atom replaced by three atoms of hydrogen; but if all the water be regarded as combined, the statement takes the following graphic form:



Xenolite.



Westanite.



Kaolin.

The suggestiveness of such formulæ can hardly be questioned, and a close examination of them will show that they also fulfill the main purpose of structural formulæ; namely, that they indicate probable lines for fruitful synthetic research.

One more question may be included within the scope of the present paper. What has become of the fluorine withdrawn from the topaz during the process of alteration? The answer is probably not far to seek. Leached out from the topaz in the form of alkaline fluorides, it entered into new modes of union, and these are represented at the locality by the species fluorite, herderite, triplite and apatite. The last-named mineral occurs in small crystals, and also in large, dark-green masses. As an analysis of the massive apatite was made by Mr. Whitfield, we subjoin it, as a further contribution to our knowledge of the locality. The specific gravity was 3·27, and the mineral became colorless on heating.

CaO	47·60
MgO	6·08
FeO	1·44
P_2O_5	40·36
Cl	0·29
F	6·84
H_2O	0·11
	102·72
Deduct oxygen	2·94
	99·78

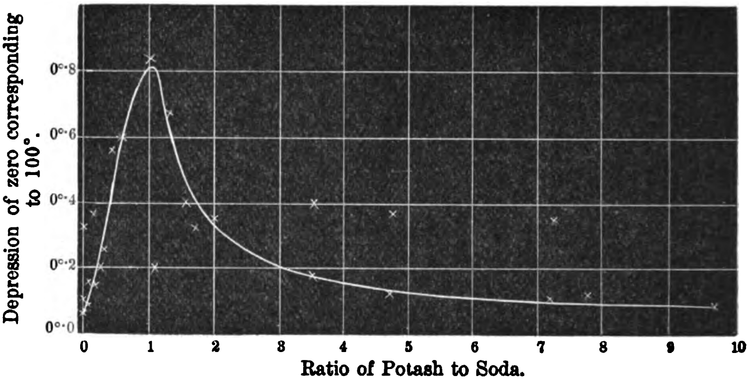
The high proportion of fluorine found in this analysis was undoubtedly due to intermixed fluorite. The large amount of magnesia, moreover, suggests the desirability of a careful search at the locality for wagnerite.

In conclusion, we must express our indebtedness to Mr. Whitfield for the care and thoroughness with which he executed the troublesome analyses.

ART. L.—*A notice of the relation observed by Dr. Weber between the residual elasticity and the chemical constitution of glass;* by O. T. SHERMAN.

IT is well known that the temperature of a bath, measured by a thermometer which has been long unused, is somewhat greater than when measured by the same thermometer immediately after it has been heated to a higher temperature. With a bath near the temperature of melting ice and a thermometer previously immersed in the steam of boiling water the depression may amount to a degree. The effect varies with the constitution of the glass forming the bulb. In any glass the depressions are capable of being expressed by an algebraic formula and the amount may be calculated. To make the temperature record independent of the condition or past history of the thermometer has proved a rather complex problem. The earliest attempts, regarding the depression irregular, adopted as the fundamental distance the interval between the freezing and boiling points obtained after a long rest, and for the false position of the zero, applied a correction proportional to the first power of the temperature. In 1880 it was shown that better results were obtained by considering the interval between the fixed points obtained directly after heating as the fundamental length, and calculating the position of the zero by a formula depending upon the second power of the temperature. A third method determines the errors of the instrument directly after it has been heated to the boiling point, and for lower temperature uses the instrument only when in the same condition. To diminish the uncertainties from this cause the Normal-Archungs-Commission has for some time past been analytically and synthetically examining the constitution of the glass which gave the least depression. In volume xxxvi of the "Sitzungsberichte der Königlich Preussischen Academie der Wissenschaften zu Berlin," Dr. Weber has recently stated as the first result of their work: that glass has the least depression in which the ratio of soda to potash or potash to soda is the least. In a previous number of the same publication, Dr. Weber has given twenty-three analyses of the glass together with the observed depression. It is a matter of interest to discuss these with regard to the same point. In the following curve we have represented the records of both articles. The ordinates represent depressions in tenths of a degree centigrade, the abscissæ, the ratio of potash to soda.

It will be seen that while the greater portion of the observations may be represented by a smooth curve yet six or at least five lay farther from the line than can be ascribed to error of observation. In some of the irregular cases the composition of the glass is almost identical with some of those that lie on the curve. With one exception the departures are less than the maximum differences afforded by the depressions observed by Dr. Weber on a single thermometer. These latter, for example, amount to 0·21°, 0·29°, 0·35°. May it be that for certain proportions of soda and potash the depression becomes less regular? The single remaining exception, the only case where the depression is decreased, is unique in having the lime, soda and potash in nearly equal amounts. The Commission still continue the investigation.



Art. LI.—*On the Meridional Deflection of Ice-Streams;* by W. J. McGee.

I.—The Phenomena.

Five Quaternary glaciers, averaging eight miles in length, flowed down the picturesque easterly front of the cloud-capped Sierras into the broad valley of Mono lake in Eastern California. The glaciers have melted away beneath the withering winds of the geologic to-day; but their magnificent moraines tell of their magnitude and of their movements.*

The lateral moraines of four of the glaciers extend far upon the plain in which the lake is embosomed; while those of the fifth terminate on a narrow plateau bounded lakeward by an outlying butte. These five pairs of moraines possess the common feature of distal curvature northward.

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* These and other moraines are described in detail by Mr. I. C. Russell (under whose direction they were observed by the writer), in his memoir on the Quaternary history of Mono Lake, designed for publication in the forthcoming Sixth Annual Report U. S. Geological Survey.

Of the northernmost pair, issuing from Lundy cañon, the left-hand (northern) moraine is narrow and steep-sided—rising on both inner and outer sides at an angle of some 30° to an altitude of fully four hundred feet,—and curves northward so sharply as to almost follow the mountain-wall in which the cañon is excavated. The inner side of the right-hand moraine is equally steep and of concentric curvature; but its summit forms an undulating plateau half a mile broad, expanding, fan-like, toward its extremity, and sloping gently outwardly and distally toward the lacustral plain of Mono, into which it gradually merges. Near its origin in the embouchure of the cañon, the highest of the Quaternary lake-terraces encircling the valley is as distinctly scored upon the outer slope of this moraine as upon the contiguous mountain-side; but toward its extremity the wave-marks become progressively fainter and finally obscure. Beyond occur fractured and contorted lacustral strata overlain by only five or ten feet of coarse littoral deposits, indicating that the glacier reached its greatest extension just before the waters attained their highest level.

In its upper course, Leevining cañon is a deep, narrow chasm, but it expands lakeward and opens on the plain in a broad breach bounded on the south by the isolated butte behind which the Gibbs cañon glacier terminated; and its moraines originate with the expansion. That on the left is narrow, steep-sided, and sharp-crested, and closely hugs the northern cañon-wall nearly to the wide embouchure, where it attenuates and finally disappears, leaving only the precipitous mountain-side for the northern confine of the ancient ice-way. The right-hand moraine sweeps about in a concentric curve interiorly, but has a multipartite crest, widens distally, and exteriorly sends off four or five digitiform radial spurs obviously the right-laterals of successive stages in the development, repeated oscillation, and final decadence of the glacier; while, unlike its constricted northern fellow, it shuns the southern cañon-wall, leaving a considerable valley between moraine and mountain-side.

The moraines issuing from Gibbs cañon are of consonant behavior: that on the north is compressed, and finally abruptly terminated by the chasm through which this ice-stream, in its later stages, approached and perhaps became confluent with the deeper Leevining glacier; while a broad morainic plain, diversified by half a dozen obscure radial lobes, forms the left lateral and occupies the greater part of the plateau separating Leevining and Bloody cañons. These moraines record the gradual shifting of the periodically oscillating ice-stream from the southern to the northern margin of the plateau, and its ultimate coalescence, just before the final recession of the ice—with its northern neighbor.

Bloody cañon embouches into a broad bay forming the southwestern arm of Mono valley. Its magnificent moraines do not closely approach either side of the bay after leaving the cañon proper; but their northward curvature is pronounced. That on the right is conspicuously the broader and more massive, and sends off two or three digitiform lobes analogous to those of the Leevining and Gibbs moraines; and midway of its length a symmetric pair of perfect laterals spring from its graceful curve like the tangent from its chord, and extend directly into the bay nearly as far as do their more recent homologues. Here the deflecting agency manifestly forced the fluctuating ice-stream to burst its old barriers and build for itself a new pair of adequate curvature.

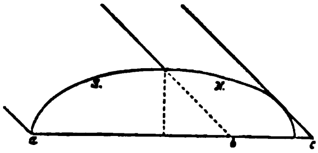
The southernmost of the five pairs of moraines issues from Parker cañon and extends two or three miles upon the long alluvial slope everywhere forming the periphery of the plain of Mono. They curve northward more sharply and approach the northern cañon-wall more closely than do those of Bloody cañon; but the right-hand member does not so greatly exceed its fellow in magnitude.

Let it be clearly understood that in these several cases the curved portion is well without the cañon proper and unquestionably beyond its influence, and that the curvature, so far as can be detected by careful observation, is independent of if not opposed to topographic configuration, whether ancient or recent. So uniform behavior must have a common cause; and this may be sought analytically.

II.—The explanation of the phenomena.

Let an ice-stream flowing east or west on a meridionally horizontal plain in N. lat. 45° have cross-section bounded above by the transverse semi-circumference of an ellipse whose axes are 2 and 1 respectively; and let the sun be over the equator. The proportion of solar rays directly reaching the south and north halves respectively, will then vary as $a-b:b-c$ (fig. 1); or, making the major semi-axis unity, as 1·5000 to 0·6547 (= sec. 30° − 0·5000), since the secant formed by the tangential ray in such case is demonstrably equal to the like function determined by the tangent to a circular arc of value 30°. The relations are graphically shown in fig. 1.

1.



The whole of the solar energy reaching the ice-stream will not, however, be utilized in affecting its condition;—a considerable portion will be lost by direct reflection; and of the remainder the discordant (and hence heating) rays will have been in part absorbed by the vapor of the superfluitant atmosphere; but the diminution will be proportional.

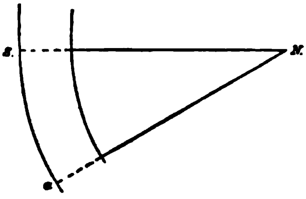
Again, an important share of the heat absorbed by the glacier will be derived from the surrounding air, from the earth beneath, and, by reflection and radiation, from contiguous earth, rocks, hills, etc.; and this share will be pretty nearly equally distributed over the entire surface. If half the effective heat reaching the ice comes from such sources, the ratio of effective energy received by its respective halves will be reduced to 25773 : 17320.

Also, the differential accession of the two halves will be counteracted to a considerable but indeterminate extent by interior conduction. If the unequal distribution be thus diminished by a half, the ratio will be further reduced to 23660 : 19433.

Now, as empirically shown by innumerable observations, and as theoretically indicated by all plausible hypotheses of glacier motion, the rate of movement of ice-streams varies directly with the heat-accession or with some slightly variant function of that element. If, then, in the assumed case, the accession be incompetent to occasion loss by melting (i. e., if on any section of the stream daily accession equal nightly radiation), all will be effective in producing movement, the two halves will tend to flow at rates varying with the accession, and the stream will hence tend to curve in the direction of the slow-moving side.

Such tendency will be counteracted in part by (1) the mobility of the ice (which will permit the southern half to the more readily spread laterally and to slip past the northern half to some extent), and (2) by the increased friction encountered with lateral shifting of the stream. Accordingly, the loci of flow in the determined ratio will lie somewhere without the centers of the respective halves—perhaps at the extreme edges of the glacier; when these edges will curve northward in concentric arcs of 23660 and 19433 respectively, or of 5598 feet and 4598 feet radii if the width of the stream be 1000 feet. Such curvature is shown in fig. 2.

2.



If the direction of flow depart from the parallel, other elements are introduced. To facilitate their comprehension, let the ice-stream be assumed to flow north or south upon a plain horizontal in the trans-meridional direction; and, as before, let the heat accession be supposed insufficient to produce melting. Neglecting interception by clouds (which is rendered nugatory by concomitant diminution of diathermancy and increase of liberation of latent heat by condensation of vapor), insolation on the two halves of the glacier will then be equal; but the influence of the thermal energy in affecting the mobility of these halves will become unequal by reason of (1) the variable condition of the atmosphere, and (2) the diverse offices of the absorbed energy, at different hours.

The diurnal inequality in temperature is notable in most and appreciable in all stations affected by glaciers; so, in such stations, the forenoon is lower than the afternoon temperature. In general, atmospheric diathermancy varies inversely with temperature, and afternoon precipitation predominates, in glaciated as in most other stations. Accordingly, the solar accession of the east half of the assumed ice-stream will be freely dissipated through the diathermous forenoon atmosphere, while the west half accession will be not only conserved by the athermous afternoon atmosphere, but supplemented by the latent heat liberated by afternoon precipitation.

The thermal energy derived by the glacier from all sources is arbitrarily divisible into two shares expended respectively in molecular and molar work, or in (1) elevating the temperature of the ice from that of inter-stellar space to that of mobility, and (2) mobilization. During the forenoon when east half insolation predominates the share of energy absorbed in molecular work is larger, by reason of the lower temperature to be overcome, than during the afternoon when the west half faces the sun. It follows that the share of energy available in mobilization during each day will be the greater in the west half of the glacier.

Thus the west half of the meridionally-moving ice-stream not only absorbs more heat than the eastern half, but utilizes a larger proportion of it in generating movement; whence it must tend to outrun its eastern mate, and thus to originate eastward curvature of the stream. Such tendency depends for its strength upon many obscure elements, and hence cannot be quantitively expressed. It is probably slight in the case of the meridional ice-stream and of progressively diminishing value as the direction of flow approaches the parallel; but it cannot be neglected.

So many of the factors essential in the foregoing analysis are indeterminate or variable that the numeric ratio deduced above can only be regarded as a vague approximation even in the simplest case; and it is accordingly needless to deduce in like manner similar estimates for different latitudes, for the several seasons, and for diverse directions of flow.

The relation of the factors is such, however, as to indicate the general law that *ice-streams flowing upon plains are deflected toward the sides upon which effective solar accession is least.*

The law is modified in its action by conditions originating with the formation of moraines by the ice-stream, and by conditions affecting the origin of the ice-stream itself.

In nature the ice-stream, after leaving its parent cañon, flows not upon a plain but in a trough whose walls it builds upon the plain. Now after its first formation the northern moraine must ever oppose the tendency to further deflection; and moreover, with the development of the moraines the surface of the stream will diminish in convexity. In nature, too, some melting of the ice will surely occur, and whatever energy is expended in liquefaction will be diverted from mobilization; and since liquefaction will occur chiefly on the south side, that side will be attenuated and rendered less competent to deflect the stream. For these four reasons will the deflection tend to fail of that computed.

If, however, the northern moraine be forced outward by the impinging ice, the stream will follow it and leave a gash between ice and moraine on the south to be filled with supraglacial debris; and whatever melting and attenuation the south side suffers, will lower that side, shift the medial axis northward, and bring more than its share of debris to the southern moraine; which thus for two reasons will tend to widen.

But again, in nature the ice-stream does not possess constant volume and length; it alternately expands and contracts, vertically, laterally, and longitudinally. In its contraction both moraines will be reinforced by semi-terminal deposits greater on the south, but their status will otherwise remain unchanged. In its expansion, however, it will press upon both moraines; when if either yield it will be the weaker northern one. Also the old channel will be plowed out anew; when, if the curving glacier hug its northern wall, there will the furrow be deepest and the lateral abrasion greatest. Moreover, the swelling stream will eventually overtop its ancient banks and discharge on and over their summits its superficial debris; when that on the north will fall beyond the narrow crest and roll down without, while that on the south will spread itself over the already broad-topped ridge. Thus for three further reasons will the meridional deflection tend to approach that computed.

Finally, if the oscillating glacier break out of its trough, the trench will occur in the feebler and more strongly constrained northern barrier.

Within the cañon proper two antagonistic elements ever work. The greater number and extent of tributary glaciers on the northerly slope will increase both ice and debris there, and thus tend to deflect the stream northward and build up the southern moraine; while on the southerly slope the greater variability of temperature will augment disintegration and the more effective reflection and radiation will accelerate the flow on that side, and thus tend to deflect the ice-stream southward and build up the northern moraine.

The modifications in the action of the general law due to external conditions are, accordingly, not such as to affect its validity or materially reduce its potency.

The law of meridional deflection of ice-streams here educed appears adequate to explain the common curvature of the moraines of the Sierras.

February 18, 1883.

ART. LII.—*The Pre-glacial Channel of Eagle River, Keweenaw Point, Lake Superior;* by CHARLES WHITTLESEY.

INTRODUCTION.

IN the year 1854, the author examined the scattered and mutilated maps made in the progress of mining at the Phœnix location, on Keweenaw Point, Lake Superior, and compiled from them, with the aid of the descriptions of Superintendent Hill and Captain Paul, a map and a series of profile-sections that illustrate the main features of the mining operations previous to that date. In an accompanying letter to Superintendent Hill, under date of December 27, 1854, he communicated some discoveries relative to an ancient and deeply-buried channel of the Eagle River. At that time such facts were regarded more as curiosities than as valuable data. Recently, however, more attention has been given to this class of phenomena, and all facts relating to the ancient drainage systems are regarded as having permanent value. So much of the report as relates to this subject is, therefore, now given to the scientific public with some unimportant modifications, made for the convenience of the reader, who might not otherwise readily understand some of the references. The maps and sections have been reduced and somewhat simplified by the elimination of matter not deemed important to science.

DISCOVERIES IN THE PROGRESS OF MINING AND INTERPRETATION OF THE RESULTS.

The papers found in the Phœnix Mining Company's office relating to the working of their mine in 1846 and 1847 were carefully examined. The plans, surveys, levels and sketches of Mr. Martin Coryell were found to be very numerous, but were mutilated, and many had been lost. Without the personal explanations made by Superintendent S. W. Hill, and, particularly, those of Captain Paul, of the North America Mine, it would have been very difficult to have made from these fragments a reliable plat, which should show the state of the old works. I did not ascertain how much of the material that related to the first three years of their operations under the old charter was preserved by the Company's agents in Boston.

The works were so singular as to interest every one acquainted with mines or mining geology; and there were, in those first developments, certain facts shown that were of economic value as well as scientific interest. But my object in bringing together on one map-sheet the information left by Superintendent Coryell was at first one of mere curiosity. The plan and sections, which were thus produced, show, I think, all the material features of the old works, and represent them in very nearly their correct positions and proportions. They are sufficiently full and well explained on the sheet itself, so that little remains to be said in reference to the mine-work proper. I have connected with the plans, such geologic profiles as are necessary to illustrate the ancient state of things; and have laid down the different beds of trap rock which originally held the copper, that was found in the form of water-washed bowlders.

After the shaft marked No. 2 on the map had been sunk in the rock near the bank of Eagle River, to the depth of 62 feet, a cross cut was made to the east from the bottom of the shaft. This was done to explore the ground. To the great astonishment of every one, the miners, at a distance of about 20 feet from the foot of the shaft broke through into sand and gravel. This was 32 feet below the channel of the river (really but a creek, at this point), where the water was then flowing. It happened, also, to be on a level with the bottom of the drift-filled gorge; so that the miners proceeded along its rocky floor in the hope of further discoveries. A few feet forward, they cut the back of a well defined vein. A mass of earth, bowlders and gravel lay on either hand and overhead, and was so compact as to stand firmly as the gallery progressed. Captain Paul thinks it remains so now, although very little timber was put in.

The general direction of the glacial striæ on Point Keweenaw is from the northeast towards the southwest, and therefore within about 25° of a perpendicular to the course of the ancient channel of Eagle River, at the Phœnix Mine. In moving across the old channel the pressure of the ice mass was such that the drift materials were made nearly as compact as rock. Glaciated surfaces in the vicinity reach upward from the lake level to the top of the semi-mountainous range, an elevation of 700 to 1,000 feet, from which it appears that the ice had a very considerable thickness.

At the point where the miners happened to strike the rock floor of this old channel, there was a steep rise in the rock bottom, on the right hand side; and they followed awhile along the foot of this slope. The boulders that were found in the "hard pan" were held firmly in it, either by pressure or by cement, and were of various kinds of rock, as sandstone, trap, granite, porphyry, etc., the same as are common in the Lake Superior drift-deposits. These were very much water-worn. On the back of the vein, and in its vicinity, there were rounded lumps, and grains of native copper, of all sizes, some of them still bright and shining.

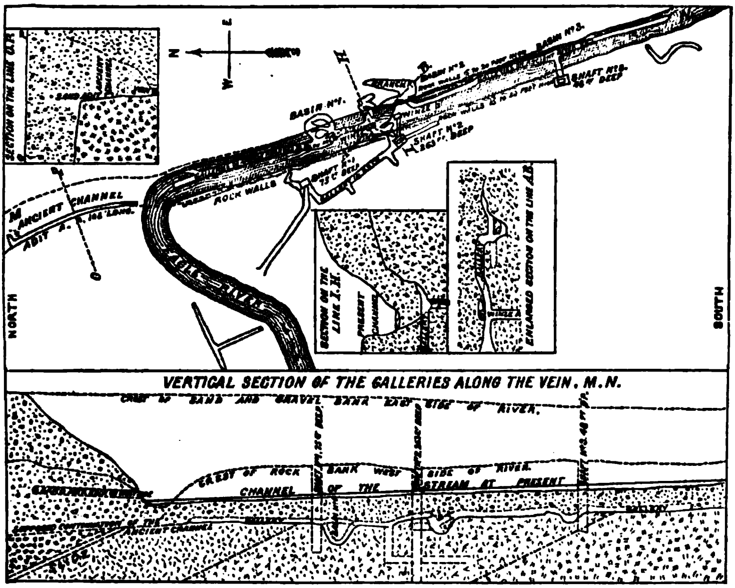
These discoveries tempted them on; and turning to the left or to the north, they followed along the vein. They were evidently in the bed of an ancient stream, the predecessor of the Eagle River, as it existed at some remote period. Along the lowest part of this lay the vein which perhaps determined the course of the stream. For about thirty feet the floor was not found to be very uneven, but, as it here sunk below drainage level, a branch gallery, D, was started obliquely to the right. At 27 feet, in this direction, the gallery being entirely in drift, a rock face was struck. The gallery, thus made, proved to be the diameter of a circular cavity, (marked "Basin No. 1," on the map) which was found to be 17 feet deep.

The miners then followed around the rim of the basin, and also descended nearly to its bottom, taking out large quantities of loose copper and copper-bearing gravel. One mass, from the level, near the basin, weighed 1,760 pounds. This basin appears to be a gigantic pot-hole.

On the northwestern quarter of the basin, a narrow fissure was discovered, which represented the vein; and along this the miners worked to the distance of 174 feet from winze A (see map), which had already been sunk on the vein. The bottom of the gallery in this direction was not very uneven, and descended but slightly to the north. The earth of the gallery sides remained firm; but on the 16th of November, 1846, a stream of water was struck which discouraged the superintendent, and the work was abandoned.

The stream copper was found to lie always next to the rock, and not intermixed with the drift material above. It was collected most abundantly in the concavities and irregular depressions of the floor, but it was not sufficient in amount to pay the expense of mining.

When it was abandoned, the gallery had reached a point almost directly underneath the bend of the river, as shown on the map. On the surface, directly beyond, was a face of rock rising from the water 15 or 20 feet. The present channel of Eagle River below the bend has rocky sides and a rock bottom, the lowest part of which is at least 20 feet higher than the end of the gallery.


N
E
W
SECTION ON THE LINE O.P.
SAND ADIT
ANCIENT CHANNEL
BASIN No. 1.
BASIN No. 2.
BASIN No. 3.
BRANCH
ROCK WALLS
SHAFT No. 1 75 FT. DEEP
SHAFT No. 2 36 FT. DEEP
SHAFT No. 3 46 FT. DEEP
WINZE
H
M
ANCIENT CHANNEL
ADIT A. A. 168 LONG.
O
EAGLE RIVER
SECTION ON THE LINE I. H.
PRESENT CHANNEL
ENLARGED SECTION ON THE LINE A.B.
WINZE A
NORTH
SOUTH
VERTICAL SECTION OF THE GALLERIES ALONG THE VEIN. M.N.
CREST OF SAND AND GRAVEL BANK EAST SIDE OF RIVER.
CREST OF ROCK BANK WEST SIDE OF RIVER.
CHANNEL OF THE STREAM AT PRESENT
GALLERY
SUPPOSED CONTINUATION OF THE ANCIENT CHANNEL

These facts raise the question: Where did this ancient channel discharge itself? The river between shafts numbered 2 and 3 has rock walls on both sides rising 15 or 20 feet high. Near shaft No. 2, the east wall disappears beneath sand and gravel, which rises from the water level on the east bank about 90 feet. From shaft No. 2, to the bend, the rock is seen in place only on the west side. The branches subsequently worked did not disclose a vertical face on the east side, like the one on the west, but such a one must exist somewhere beneath the gravel.

On the north side of the creek, at the bend to the west, an adit A, A, was driven in along a vertical wall corresponding in direction to that of the west bank, in the expectation constantly of striking the vein. It kept the wall on the left hand for a distance of 108 feet, no rock being found on the right or bottom. A cross heading was then cut 12 feet to the east, but no rock found in place. The bottom of this adit is about 50 feet higher than the gallery along the bed of the ancient channel, the extremity of which is nearly under the mouth of the adit.

Notwithstanding the want of success in this direction, the managers continued to work the galleries which joined at winze A, in various directions, taking out a large amount of float copper, and of gravel bearing sufficient copper to pay for washing. Among this were found frequently pieces of native copper and silver united in a single mass, but each metal in its pure state, without alloy.

The bed of the ancient channel was found to descend to the north by offsets or sudden leaps which were doubtless ancient falls. In its bottom were also pockets, precisely like those of the present channel, where the descent is rapid over ripples and ledges. Captain Paul, who worked in those levels, says: "No one could mistake the cavities and pot-holes for anything else than the action of running water."

Going south the vein was well defined, both walls being visible most of the way, and well charged with copper. But the loose copper gradually diminished, and in May, 1847, at a distance of 260 feet from winze A, the work was suspended.

The strata of trap through which the vein passed and in which it bore copper are as follows: Beginning at the north, or left hand, there is a coarse porous bed of amygdaloid, which Mr. Coryell cut in his adit at 52 feet from its mouth. This dips to the north at the usual angle of 25°. Under it is a close-grained, bluish-black, compact bed of trap, about 50 feet thick, which has a basaltic, or columnar, structure. Underneath this is "the slide," which is so distinctly shown at the Copper Falls Mine, west vein, near shaft No. 5. The bed beneath "the slide" is a rough mass intermediate in character between a breccia and a conglomerate, embracing nodules of sandstone and of scoriaceous tufa imbedded in a dark brown trap. Shaft No. 1, was sunk in this bed, which was found to carry "shot copper" near the middle of its mass. Its thickness is irregular, but, on an average, is about 50 feet. It rests on a bed of black, fine-grained, compact trap from 80 to 100 feet thick, extending on the surface from shaft No. 2, to some 100 feet south of shaft No. 3. This "black band" has well-defined faces and dips to the north at the usual angle. Beneath this is a soft, greenish-gray bed of great thickness in which the workings of the new company are principally situated.

The stream copper lay in the scoriaceous, or "ash-bed," stratum, and in the "black band" beneath it. As these pitch to the north at an angle of not more than 25° with the horizon, they pass away from the recent works, so that they were not proven by the sinking of shaft No. 3, or the levels connecting with it. These beds should carry copper in the vein as they descend northward toward the lake.

There can be no doubt that the river, before the drift period, held on its way to the lake along the course of the vein, and did not then turn to the left, as it does at present. Without doubt its bed continued straight along the face of the rock seen in the adit A, A, and 35 or 40 feet beneath it, and presented at that period an open gorge like the present one, only deeper and wider. The whole was filled up to the depth of 100 to 120 feet, by the agencies that brought in the drift material. During the period next preceding the drift epoch, and while the stream of water ran along the back of the vein, it wore away the vein matter and wall rock leaving the masses of copper at rest in its channel. With the facts shown by the plans and sections I do not see how any other explanation is applicable. The ancient channel perhaps had its discharge at a lower level than the present one, and somewhere to the northward, either again joining the present course, or reaching the lake by a separate mouth.

Captain Paul represents the vein in the "sand galleries" [galleries excavated in drift material, instead of rock] along its whole exposure of more than 400 feet, as well charged with copper, and is confident that the same "pitches" of rock carry copper in masses. The floor of the "sand gallery" is about 175 feet above the lake. The dip of the strata carries the copper-bearing beds to the north, as they descend, about two feet horizontally for one vertically, or a distance of 350 feet in the depth of 175, i. e., to the lake level. The true approach to these beds is therefore from the north and at the lowest practicable level.

ART. LIII.—*Note on the Age of the Slaty and Arenaceous rocks in the vicinity of Schenectady, Schenectady County, N. Y.;* by S. W. FORD.

THE slaty and interstratified arenaceous rocks in the neighborhood of Schenectady, N. Y., have usually been referred to the epoch of the Lorraine Shales. They were considered to be of that age by Mather, who gives several sections of them, in their more eastward extension along the valley of the Mohawk, on page 376 of his Report on the Geology of the First District of New York; and the same view appears to have been held by Emmons (Agriculture of New York, vol. i, pages 134, 135, 1846). Later, Mr. R. P. Whitfield, in a letter addressed to Dr. C. A. White, and published in Part I, vol. iv, of Lieut. Wheeler's Reports on Geographical and Geological Surveys west of the 100th meridian, considers the Schenectady rocks to be of Lorraine age, but does not support his position by the evidence of fossils obtained at that locality. He also refers to the Lorraine certain "disturbed and nearly vertical layers" occurring in the valley of the Norman's Kill, near Albany, which, he says, are lithologically undistinguishable from the rocks at Schenectady; and places the Norman's Kill Graptolitic beds, which are met with only a few hundred yards distant, in the Utica formation. Mr. Whitfield is quite possibly correct in considering the nearly vertical layers above spoken of identical with the Schenectady beds; but it by no means follows from this that the layers are Lorraine, or that the Norman's Kill Graptolitic beds are Utica.

The rocks at Schenectady are nearly horizontal, or with only a slight inclination to the southward, and continue in that position for three or four miles to the east. Not far from Rexford flats a break occurs, and from that point all the way to the Hudson the rocks are greatly tilted. The break here alluded to Dr. Emmons considered identical with the fault occurring at Saratoga Springs and Baker's Falls; and believed it to pass somewhere between Albany and Schenectady, and to be traceable in its effects as far south as Kingston. It appears to hold the same relation to the Great Appalachian fault that the Montmorency break does in Canada. I have never examined with care the slaty rocks directly *east* of the break along the valley of the Mohawk; but from the nearly horizontal beds to the west of it, in Wandell's quarry, a short distance back of Union College, at Schenectady, I have obtained good specimens of *Graptolithus pristis*, *G. mucronatus* and *Triarthrus Becki*; and from another quarry, a little to the west of Rexford flats, I have obtained the *G. pristis*, *Triarthrus Becki*, and a species of Lingula which I consider to be the Utica species *L. curta*. The slates and sandstones in the vicinity of Schenectady are, therefore, in my estimation, of Utica age. I find that the arenaceous layers are different in their make-up and aspect from those of the Lorraine that I have examined, and more nearly resemble those of the Utica formation of Northern New York. The rocks are poor in fossils; but fossils nevertheless exist, and may be found by diligently searching for them.

Schodack Landing, N. Y., March 5th, 1885.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Freezing Point of Saline solutions.*—RAOULT has continued his researches on the action of dissolved substances in lowering the freezing point of solutions, and has now given the results of his experiments upon salts dissolved in water, classifying these: 1st, according to the value of the metallic constituents, and 2d, according to that of the metalloid or negative substance. In the first series, the salts are those of potassium, sodium, ammonium, silver, lithium, cæsium, and trimethylethylammonium. The tabulated results show that different salts of the same group, i. e., containing the same number of metal atoms in the molecule, show nearly the same molecular depression of the freezing point. The first group of this series, consisting of salts containing only one atom of the monad metal, gives values for the molecular depression varying from 27 to 36.* The second group, the salts of which contain two atoms of monad metal, gives the value 40. The third group, in which three monad metal atoms are contained in the molecule, gives the value 48. The fourth gives 47, and the fifth 48. The second series contains the salts of dyad metals, and the molecular depression does not exceed 53; the values being 41 to 48 for the salts of monobasic and 18 to 22 for those of dibasic acids. Comparing the two series, it appears that whenever in a molecule of a salt dissolved in 100 c. c. of water, one atom of an alkali-earth or earth dyad metal is replaced by an equivalent quantity of a monad metal, the lowering of the freezing point increases by a nearly constant quantity, viz: about 21. Referring the matter to equivalents, the author states his results in this form: If in the solution of an alkali-salt, containing one equivalent of the salt in 100 c. c. of water, the monad metal be replaced by an equivalent quantity of a dyad or polyad metal, the depression of the freezing point is diminished by a quantity sensibly constant and equal to 10·5. With regard to acids, the law given is as follows: If in the solution of a salt of a strong monobasic acid, containing one equivalent of the acid in 100 c. c. of water, the monobasic acid be replaced by an equivalent quantity of a strong dibasic acid, a diminution of the depression of the freezing point is observed which is nearly constant and approaches 14. From these data the author calculates the depression due to the separate radicals. Thus the electronegative monad radicals, such as Cl, Br, OH, NO_3, produce a partial depression of 20; the dyads, as SO_4, CrO_4, one of 11; the positive monad radicals, as H, K, Na, NH_4, a depression of 15; and the polyads, as Ba, Mg, Al_2, one of 8. From these partial values the molecular depression of any salt

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* The molecular depression produced by a salt is obtained by multiplying the lowering of the freezing point of a solution containing one gram in 100 c. c. of water, by the molecular weight.

can be calculated from its molecular weight.—*Ann. Chim. Phys.*, VI, iv, 401, March, 1885. G. F. B.

2. *On the Influence of light on Chemical Reactions.* — Some time ago SCHRAMM pointed out that the action of bromine upon crude bromtoluene or upon a solution of parabrom-toluene in chloroform produced parabrombenzyl bromide even at 0° C., and hence that the substitution of an atom of hydrogen for bromine in the lateral chain did not require the aid of heat. The change takes place, however, slowly in diffused daylight, and much more rapidly in sunlight. The author has studied the phenomenon more closely and now concludes that the action of light is essential to it. If the solution of bromtoluene in chloroform is feebly colored with bromine as by blowing bromine vapor through it, and then placed in the dark, no action whatever takes place. But light decolorizes it at once with evolution of hydrogen bromide. The action of light upon the bromination of ethylbenzene is of particular interest because not only is this hydrocarbon under these conditions highly sensitive to the action of light, but it yields different substitution products according to the intensity of the light acting. If ethylbenzene is slightly colored with bromine, no decolorization takes place in the dark; but it loses its color at once in daylight or when exposed to burning magnesium. If a molecule of bromine be made to act on a molecule of ethyl-benzene in diffused light, a colorless liquid product is obtained which does not solidify at −20°. On distillation, HBr is evolved and a distillate is obtained between 140° and 190°, a dark brown residue remaining in the retort. No bromine product of constant boiling point could be isolated. The fraction between 140° and 160° united directly with bromine and solidified, forming dibromstyrene. The fraction boiling at 180°–190° did not combine with bromine and was probably styrene-ethyl ether. When the ethyl benzene is treated with a molecule of bromine in direct sunlight the reaction is violent and the final product is α-phenyl-bromethyl $C_6H_5—CHBr—CH_3$. More curious still is the replacement of the second hydrogen atom by bromine. If the operation be conducted in full sunlight the product is phenyl-bromacetene $C_6H_5—CBr_2—CH_3$. While if diffused daylight only be allowed to act upon it, the product is dibromstyrene $C_6H_5—CHBr—CH_2Br$.—*Ber. Berl. Chem. Ges.*, xviii, 350, Feb., 1885.

G. F. B.

3. *On the Salts formed by Tellurium with Acids.* — KLEIN and MOREL have examined the compounds formed by tellurium with acids and have described the sulphate and the nitrate. Tellurous nitrate is obtained by dissolving finely divided tellurium in an excess of nitric acid of sp. gr. about 1·15 heated to 50°. By concentration the salt deposits on cooling in beautiful needles probably orthorhombic. Analysis shows it to be a basic nitrate of the formula $(Te_2O)_4N_2O_5$, $1\frac{1}{2}H_2O$. It is very easily decomposed by water and is very hygroscopic. When in solution it decomposes slowly in the cold, rapidly at the temperature of ebul-

lition, the nitric acid remaining in the liquid and the tellurous oxide being precipitated as a nearly white powder. Boiling for 20 minutes completely decomposes it, yielding 1·415 grams TeO_2 from 1·698 of the salt. Tellurous sulphate was obtained by dissolving the oxide in hot sulphuric acid diluted with 3 or 4 times its weight of water. On evaporating the solution on a sand bath, the sulphate was deposited in the form of scales, which under the magnifier had the appearance of orthorhombic tables. The excess of acid was decanted and the crystals dried on a plate of porous porcelain, the last trace of acid being removed by heating to the temperature of melting lead. Analysis showed this also to be a basic salt having the composition $(TeO_2)_2SO_3$. It is decomposed very slowly by cold water rapidly and nearly completely by boiling water, leaving tellurous oxide crystallized in microscopic octahedrons.—*Bull. Soc. Ch.*, II, xliii, 198, March, 1884.

G. F. B.

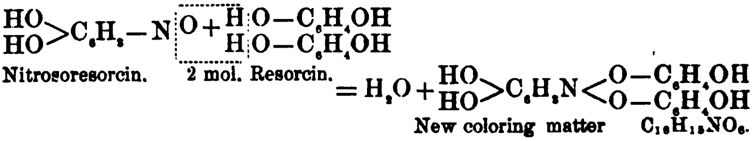
4. *On the Atomic Weight and on certain Compounds of Samarium.*—CLÈVE has published an abstract of his recent researches on samarium. He finds that the best process for its separation consists in fractionally precipitating the mixed nitrates in cold very dilute solution by a dilute solution of ammonia. Samaria concentrates in the first fractions which are subjected to repeated precipitations until the absorption spectrum of didymium disappears. To free it from yttria, etc., it is then precipitated by means of potassium sulphate, which forms with the samaria a double salt only slightly soluble in the potassium sulphate. As thus prepared it has always a yellow color from the presence of terbia, from which it may be freed by repeated precipitations with ammonia. The final fractions are nearly white. The atomic weight was determined from the weight of sulphate yielded by a known weight of the oxide. Six determinations gave the values 149·975, 149·940, 150·120, 150·045, 150·045 and 150,000, the mean of which is 150·021. So that 150 may be taken as the atomic weight of samarium. The spectrum of this element has been examined by Thalèn who has mapped 198 lines. Its remarkable absorption spectrum has been studied by Soret, by Thalèn and by Lecocq de Boisbaudran. Soret has shown the existence of bands in the ultra violet and Becquerel in the ultra red. The metal has not yet been isolated. The oxide Sm_2O_3 is a nearly white powder of density 8·347 which dissolves easily in acids. Its salts have a yellow color like sulphur or a brown like topaz. Their solutions have a sweet astringent taste, and are easily precipitated by oxalic acid, the oxalate being almost insoluble. Samarium is determined either as oxide, by igniting the oxalate or hydrate, or as sulphate which may be heated to a dull red.—*Bull. Soc. Ch.*, II, xliii, 162, Feb., 1885.

G. F. B.

5. *On the Purification of Methyl Alcohol.*—The question of the production of iodoform by the action of iodine on methyl alcohol in presence of alkali hydrates has been an open one owing

to the difficulty of completely purifying this alcohol. Even when prepared by the decomposition of methyl oxalate there still remains in it some constituent which yields iodoform. **Regnault** and **Villejean** have now proposed to effect the final purification by the iodoform method itself. The alcohol prepared from methyl oxalate has about one tenth of its weight of iodine dissolved in it, and an aqueous solution of sodium hydrate is added to it in quantity sufficient to produce complete decoloration and leave an alkaline reaction. Submitted to careful distillation methyl alcohol is obtained which when rectified over caustic lime has a specific gravity of 0·810 at 15° and which does not yield iodoform.—*Ann. Chim. Phys.*, VI, iv, 430, March, 1885. G. F. B.

6. *On Phenol Coloring Matters.*—In the preparation of nitrosoresorcin and nitrosoorcin by the action of amyl nitrite upon the mono-sodium salts of the corresponding phenols and precipitation with dilute sulphuric acid, **Brunner** and **Robert** observed that after some time dark crusts separated from the wash waters which they at first took for azoresorcin and the corresponding orcin coloring matter. But a closer examination showed that only slight traces of these bodies were present, and that the mass consisted essentially of a new material. The nitrosoresorcin crust was washed with water, dissolved in ammonia, filtered and precipitated with hydrochloric acid. A brown substance was thrown down which ether separated into a soluble and an insoluble portion. The former remained after the evaporation of the ether as a cantharides-green mass, soluble in alkalies with a blue violet color, with a brown fluorescence, and soluble in concentrated hydrochloric and sulphuric acids. Analysis gave the formula $C_{18}H_{15}NO_6$. The authors believe this body to have been produced by the action of the nitrosoresorcin upon resorcin itself according to the equation:

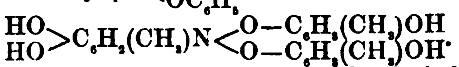


$$\begin{matrix}HO\\HO\end{matrix}\!\!>C_6H_3-N\boxed{O+\begin{matrix}H\\H\end{matrix}}\!\!\begin{matrix}O-C_6H_4OH\\O-C_6H_4OH\end{matrix} = H_2O+\begin{matrix}HO\\HO\end{matrix}\!\!>C_6H_3N<\!\!\begin{matrix}O-C_6H_4OH\\O-C_6H_4OH\end{matrix}$$

Nitrosoresorcin. 2 mol. Resorcin.

New coloring matter $C_{18}H_{15}NO_6$.

It is therefore analogous in constitution to the coloring matters obtained by Krämer from nitrosophenol and nitrosoorcin, the former being $HO-C_6H_4N<\!\!\begin{matrix}OC_6H_5\\OC_6H_5\end{matrix}$ and the latter



$$\begin{matrix}HO\\HO\end{matrix}\!\!>C_6H_2(CH_3)N<\!\!\begin{matrix}O-C_6H_3(CH_3)OH\\O-C_6H_3(CH_3)OH\end{matrix}.$$

The residue insoluble in ether was dissolved in alcohol and left on evaporation a brown mass, soluble in alkalies with a dirty violet color. It appeared to be impure and was not further examined. —*Ber. Berl. Chem. Ges.*, xviii, 373, Feb., 1885. G. F. B.

7. *Application of the Pendulum to the determination of the mean density of the earth.*—The observations of **Maskylene** and **Hutton** on the deflection of the plummet line in the neighborhood

of Schehallien are affected by an approximate knowledge of the mass and density of the attracting mountain. This error also affects the results of Carlini and Airy who used the method of oscillation of a pendulum. Generally the pendulum has been abandoned for the torsion balance. Dr. J. Wilsing, of Potsdam, however, has revived the use of the pendulum for the purpose of weighing the earth and shows that it can be made sufficiently sensitive by adjusting the center of gravity close under the axis of oscillation. An experimental apparatus consisted of a prismatic rod of thin sheet iron at the ends of which were fixed lead balls, each weighing 300 grams. The steel knife edge, which rested on agate, was fixed in the middle of the rod. When the apparatus was in equilibrium the axis was nearly vertical. The motion was read by reflexion. When the position of equilibrium was found and the attracting masses were placed near the lead spheres, from the deflection of the pendulum, the ratio of their attraction to the constant of gravitation can be determined. By reversing the direction of the deflecting forces, the action of the force can be doubled. Besides the calculation of the gravitation of the pendulum bob towards the attracting masses, which is common to all methods, two measurements are necessary—the distance of the extra weights, and of the center of the pendulum bobs from the knife edge. Dr. Wilding believes that a more perfect apparatus, which is being constructed for him by Repsold of Hamburg, will give excellent results.—*Phil. Mag.*, March, 1885, pp. 219–222. J. T.

8. *Method of studying the Electrical Potential of the air.*—M. Pellat has discovered in common with all who have used Thomson's water dropper, that this apparatus does not take the potential of the air quickly. With a discharge of 8 liters of water in twelve hours, six minutes were necessary in order to obtain $\frac{8}{10}$ of the variation of potential; and with a discharge of 12 liters, five minutes were needed to reduce the apparatus to the potential of the air. The slow match soaked in a preparation of lead, sometimes used in place of the water dropper, is less rapid in its indications than the water dropper, and moreover communicates its own potential due to combustion. This fault makes its use very undesirable for observations on atmospheric electricity. M. Pellat therefore has been led to employ as a substitute for a water dropper a small gas flame issuing from a metallic burner which is insulated from the ground and is connected with an electrometer. This burner takes the potential of the air almost instantaneously. In order to study the electrometric forces arising from the combustion of different gases, M. Pellat placed the gas burner inside a hollow metallic vessel, closed at the top and provided with holes necessary for draft; the metallic burner and the outside vessel were connected with a wire. This apparatus serves as a battery, there being an electromotive force developed, which depends: 1. Upon the nature of the gas which is burned; 2. Upon the nature of the metal of the burner, and 3. Upon the

nature of the metal which constitutes the internal surface of the surrounding vessel.—*Comptes Rendus*, No. 10, March 9, 1885, pp. 735–737. J. T.

9. *Measurement of Magnetic Force by hydrostatic pressure.*— Magnetic fluids under the influence of magnetic force show a pressure perpendicular to the magnetic lines of force, which is expressed by the equation $p=\frac{K}{8\pi}H^2$, in which H is the strength of the magnetic field, and K is a diamagnetic constant. The diamagnetic constant for atmospheric air is 1. When a magnetic fluid is surrounded by air, the difference of the magnetic pressure in the fluid and the air can be balanced by a hydrostatic pressure and can be measured by $K-1$. G. Quincke contributes a voluminous article on measurements of this character to the Annalen der Physik. The paper contains many tables of the results of measurement. The paper also contains tables of the quantity which G. Wiedemann has termed Atom Magnetism.—*Ann. der Physik und Chemie.* No. 3, 1885, pp. 347–416. J. T.

10. *A Selenium Actinometer.*—For the purpose of measuring the relative intensities of sunlight at different heights above the horizon, M. H. Morige has employed a selenium cell similar to that invented by Mr. Graham Bell. Thirty-eight discs of copper are insulated from each other by discs of mica of smaller radius; the groove thus formed is filled with selenium by being rubbed with a rod of this substance. The cylinder being suitably heated, this selenium is ready for use. The even numbers of copper are connected by one conductor and the odd numbers by another. The selenium cylinder is insulated by glass supports in the interior of a glass cylinder which is exhausted. The apparatus is placed high enough to avoid the light reflected from neighboring objects and the axis of the cylinder is placed parallel to the earth's axis. A constant current is passed through the selenium cells, and the instrument is calibrated by making measurements at first in a perfectly dark room.—*Comptes Rendus*, Feb. 2, 1885, pp. 271–272. J. T.

11. *Measurement of the Force of Gravity at Naha and Kagoshima, Japan.*—Messrs. S. Sakai and E. Yamaguchi have conducted a series of pendulum observations with the object of obtaining the data for a comparison of the acceleration due to the force of gravity at Naha (Okinawa) in the Loo Choo Islands with that at Tokio. The methods followed were essentially those followed by Mendenhall in his observations on Fujinoyama (see this Journal, xx, 124; xxi, 99). Experiments were also made by the party at Kagoshima on their way to Naha. The results obtained in c.g.s. units, as the mean of independent series with two pendulums were:

For Naha,	$g=979{\cdot}165\pm0{\cdot}0055$
For Kagoshima,	$g=979{\cdot}561\pm0{\cdot}0057$

Both values are somewhat greater than those deduced from the usual formula. Mendenhall obtained for Tokio $g=979{\cdot}854\pm0{\cdot}0044$.

12. *A Method of Measuring the Absolute Sensitiveness of Photographic Dry Plates,*[*] by WILLIAM H. PICKERING.—Within the last few years the subject of dry plate photography has increased very rapidly, not only in general popularity, but also in importance in regard to its applications to other departments of science. Numerous plate manufacturers have sprung up in this country as well as abroad, and each naturally claims all the good qualities for his own plates. It therefore seemed desirable that some tests should be made which would determine definitely the validity of these claims, and that they should be made in such a manner that other persons using instruments similarly constructed would be able to obtain the same results.

Perhaps the most important tests needed are in regard to the sensitiveness of the plates. Most plate makers use the wet plates as their standard, giving the sensitiveness of the dry plates at from two to sixty times greater; but as wet plates vary quite as much as dry ones, depending on the collodion, condition of the bath, etc., this system is very unsatisfactory. Another method employed largely in England, depends on the use of the Warnerke sensitometer. In this instrument the light from a tablet coated with luminous paint just after being exposed to a magnesium light, is permitted to shine through a colored transparent film of graduated density upon the plate to be tested. Each degree on the film has a number, and, after a given exposure, the last number photographed on the plate represents the sensitiveness on an empirical scale. There are two or three objections to this instrument. In the first place, the light-giving power of the luminous tablet is liable to variations, and, if left in a warm, moist place, it rapidly deteriorates. Again, it has been shown by Captain Abney that plates sensitized by iodides, bromides and chlorides, which may be equally sensitive to white light, are not equally affected by the light emitted by the paint; the bromides being the most rapidly darkened, the chlorides next, and the iodides least of all. The instrument is therefore applicable only to testing plates sensitized with the same salts.

In this investigation it was first shown that the plates most sensitive for one colored light were not necessarily the most so for light of another color. Therefore it was evident that the sun must be used as the ultimate source of light, and it was concluded to employ the light reflected from the sky near the zenith as the direct source. But as this would vary in brilliancy from day to day, it was necessary to use some method which would avoid the employment of an absolute standard of light. It is evident that we may escape the use of this troublesome standard, if we can obtain some material which has a perfectly uniform sensitiveness. For we may then state the sensitiveness of our plates in terms of this substance regardless of the brilliancy of our source. The first material tried was white filter paper, salted and sensitized in a standard solution of silver nitrate. This was afterward replaced by powdered silver chloride, chemically pure,—which was found to be much more sensitive than that made from the commercial chemicals. This powder is spread out in a thin layer, in a long paper cell, on a strip of glass. The cell measures one centimeter broad by ten in length. Over this is laid a sheet of tissue paper and above that a narrow strip of black paper, so arranged as to cover the chloride for its full length and half its breadth. These two pieces of paper are pasted on to the under side of a narrow strip of glass which is placed on top of the paper cell. The apparatus in which the exposures are made consists of a box a little over a meter in length, closed at the top by a board, in which is a circular aperture 15·8 cm. in diameter. Over this board may be placed a cover, in the center of which is a hole ·05 cm. in diameter, which therefore lets through ·00001 as much light as the full aperture. The silver chloride is placed at a distance of just one meter from the larger aperture, and over it is placed the photographic scale, which might be made of tinted gelatines, or, as in the present case, constructed of long strips of tissue paper, of varying widths, and arranged like a flight of steps; so that the light passing through one side of the scale traverses nine strips of paper, while that through the other side traverses only one strip. Each strip cuts off about one sixth of the light passing through it, so that, taking the middle strip as unity, the strips on either side taken in order will transmit approximately,—

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[*] From the Proceedings of the Academy of Arts and Sciences.

1	2	3	4	5	6	7	8	9
2·0	1·65	1·4	1·2	1·0	·85	·7	·6	·5

The instrument is now pointed toward the zenith for about eight minutes, on a day when there is a bright blue sky. On taking the apparatus into the dark room, and viewing the impression by gas-light, it will be found that the markings, which are quite clear at one end, have entirely faded out by the time the middle division is reached. The last division clearly marked is noted. Five strips cut from sensitized glass plates, ten centimeters long and two and a half in width, are now placed side by side under the scale, in the place of the chloride. By this means we can test, if we wish, five different kinds of plates at once. The cover of the sensitometer containing the ·05 cm. hole is put on, and the plates exposed to sky light for a time varying anywhere between twenty seconds and three minutes, depending on the sensitiveness of the plates. The instrument is then removed to the dark room, and the plates developed by immersing them all at once in a solution consisting of four parts potassium oxalate, and one part ferrous sulphate. After ten minutes they are removed, fixed and dried. Their readings are then noted, and compared with those obtained with the silver chloride. The chloride experiment s again performed as soon as the plates have been removed, and the first result confirmed. With some plates it is necessary to make two or three trials before the right exposure can be found, but if the image disappears anywhere between the second and eighth divisions, a satisfactory result may be obtained.

The plates were also tested using gas-light instead of daylight. In this case an argand burner was employed burning 5 cubic ft. of gas per hour. A diaphragm 1 cm. in diameter was placed close to the glass chimney, and the chloride was placed at 10 cm. distance, and exposed to the light coming from the brightest part of the flame, for ten hours. This produced an impression as far as the third division of the scale. The plates were exposed in the sensitometer as usual, except that it was found convenient in several cases to use a larger stop, measuring ·316 cm. in diameter.

The following table gives the absolute sensitiveness of several of the best-known kinds of American and foreign plates, when developed with oxalate, in terms of pure silver chloride taken as a standard. As the numbers would be very large, however, if the chloride were taken as a unit, it was thought better to give them in even hundred thousands.

SENSITIVENESS OF PLATES.

Plates.	Daylight.	Gas-light.
Carbutt Transparency	·7	
Allen and Rowell	1·3	150
Richardson standard	1·3	10
Marshall and Blair	2·7	140
Blair Instantaneous	3·0	140
Carbutt Special	4·0	20
Monroe	4·0	25
Wratten and Wainwright	4·0	10
Eastman Special	5·3	30
Richardson Instantaneous	5·3	20
Walker Reid and Inglis	11·	600
Edwards	11·	20
Monckhoven	16·	120
Beebe	16·	20
Cramer	16·	120

It will be noted that the plates most sensitive to gas-light are by no means necessarily the most sensitive to daylight; in several instances, in fact, the reverse seems to be true.

It should be said that the above figures cannot be considered final until each plate has been tested separately with its own developer, as this would undoubtedly have some influence on the final result.

Meanwhile two or three interesting investigations naturally suggest themselves: to determine, for instance, the relative actinism of blue sky, haze and clouds; also, the relative exposures proper to give at different hours of the day, at different seasons of the year, and in different countries. A somewhat prolonged research would indicate what effect the presence of sunspots had on solar radiation,—whether it was increased or diminished.

II. GEOLOGY AND MINERALOGY.

1. *Glacial deposits of Central North America in the Vicinity of the Bow and Belly Rivers, Canada;* by GEORGE M. DAWSON, (Geol. Rep. Canada, 1882–84).—The facts here presented by Mr. Dawson are of great interest in their bearing on the glacial history of the continent. The region especially described is just north of the United States boundary, between the meridians of 110° W. and 115° W., and about 15° of longitude west of Winnipeg. The surface rocks are of the Cretaceous and Laramie series; and on its western border, in longitude 115°, the Rocky Mountain country commences and the rocks change to Paleozoic—the Carboniferous and Devonian formations overlying the Cambrian—without any crystalline rocks. Drift covers the whole region, and averages at least 100 feet in thickness. It consists of (1) a lower bowlder clay resting on quartzyte shingle; (2) an interglacial deposit with peat; (3) upper bowlder clay, above which are stratified sands, gravels and silts. The lower bowlder clay in the section given, 80 feet thick, contains a "variable and often very considerable proportion of Laurentian and Huronian erratics," or material from the eastern water-shed, along with quartzyte fragments from the Rocky Mountains on the west, and sandstone from the Cretaceous and Laramie. The interglacial beds in the same section (at Wolf Island), are 18 feet thick, and the upper bowlder clay, having traces of stratification, 40 feet. Moraines are also described as occurring along the base of the Rocky Mountains, and the Bow River valley as holding a glacier of larger size than any elsewhere originating in the mountains of the district.

Mr. Dawson observes also that south of the 49th parallel the country from Fort Benton, on the Missouri along the MacLeod trail, is all more or less thickly strewn with Laurentian erratics. Quartzyte material from the Rocky Mountains is most abundant south of the Morris River, but with it are granites, gneisses and other Laurentian and Huronian rocks from the eastward; some at a height of 4,390 feet; 20 miles north of 49°, at 5,280 feet; near the intersection of the 113th meridian and the 49th parallel at 4,200; one Huronian bowlder near the lower part of Watertown River, 3,200 to 3,300 feet in elevation above the sea, measuring 42×40×20 feet, and another 42×30×22, and consequently exceeding a thousand tons in weight.

Mr. Dawson presents the following views with regard to the mode of glaciation of the region.

"Apart from the local glaciers of the Rocky Mountains, it is evident that the glaciation has been accomplished by some agent moving westward or southwestward from the Laurentian axis which bounds the region of the Great Plains to the east. This agent has carried with it great quantities of Laurentian and Huronian material, which in the vicinity of the 49th parallel reaches at its extreme limit a point over 700 miles distant from the nearest exposures of the parent rock, and to an elevation more than twice as great as that attained by any part of the Laurentian area. To explain this latter fact it seems now almost certain that we must assume that the western region was, in glacial times, relatively to the Laurentian area more depressed than at present. As I have elsewhere, in the publications before referred to, discussed at some length the question whether a glacier or floating ice best accounts for the facts, it is not here proposed to recapitulate the arguments. Two theories only, however, seem tenable. Either a great confluent glacier, occupying the Laurentian highlands or passing over them from the Hudson's Bay region, stretched continuously to the slopes of the Rocky Mountains, or such a glacier, extending but a limited distance from these highlands, supplied numerous and massive icebergs which floated in a great inland sea occupying the present position of the plains.

"I still believe that the latter supposition best accounts for the facts of the glaciation and glacial deposits of the plains. I would, however, point out one circumstance which seems to give some color to the former hypothesis. This is the existence of a number of *wide*, *old*, *abandoned water-channels*, which may be supposed by this theory to have carried the drainage of the country, and water produced by the melting of a great glacier of the kind implied, round its front at different periods in its retreat. The existence of these I am unable otherwise satisfactorily to explain, except on the supposition of considerable relative changes of level of different parts of the district in post-glacial times. Mr. Warren Upham has lately traced a number of such channels in Dakota (hypothetically extending his reasoning also to western Manitoba), for which he accounts by the first-mentioned or great-glacier theory.

"In the southern part of the district of the present report, and particularly in the country south of the Belly River, great old channels of the kind above referred to are displayed in a very striking manner in Verdigris, Etzi-kom, Pā-kow-kī and Chin Coulées and their tributaries. These resemble old river valleys long disused and now carrying little or no water. I am inclined to regard them as a portion of the earliest drainage system of the plains, outlined at the time at which the waters which distributed the stratified materials overlying the bowlder-clays first subsided, and when the rainfall of the region was considerably greater than at present. That these first channels have not, in the particular part of the region now referred to, continued to be the drainage-channels of the country is perhaps in part due to the much greater depth and importance rapidly attained by the valleys carrying copious and perennial streams derived from the mountains.

"In the entire obliteration of the original southeastward slope of the valleys of Verdigris and Pā-kow-kī Coulées, and other peculiar circumstances referred to in a previous part of this report (p. 14 c), in connection with their present aspect of Milk River, as well as in several local details respecting the relations of the present drainage and the old channels, we appear to find evidence of *a greater amount of elevation of the southern as compared with the northern part of the district.** So far as it has affected these old drainage-channels this must have occurred in immediately post-glacial times, and may have been a continuation of the same process which has resulted in the present much greater elevation of erratics in the southern as compared with the northern part of this region.

"Unless explained by relative differences in level during the Glacial period, such as those above suggested, between the Bow River country and that near the 49th parallel, the absence of Laurentian erratics over the region west of Calgary can be accounted for only by the existence of Rocky Mountain glaciers of sufficient size in this region to fend off the eastern glaciating agent. It is not improbable that such glaciers obtained, and if they can be proved to have existed, it would also prove, in the most convincing way, the approximate contemporaneity of action of the glaciating agents of the Rocky Mountains and Laurentian region. It is certain, however, that the glaciers of the mountains had somewhat decreased before at least the final period of dispersion of Laurentian erratics, for these have been found overlying distinct morainic material of Rocky Mountain origin.

"That *the elevation of the western as compared with the eastern part of the plains, was relatively much less in Glacial times than at present,* seems a reasonable supposition, but must be regarded no longer as merely an hypothesis, for the position of the interglacial materials in the bowlder-clay offers a strong positive argument in its favor. It must be supposed that these beds, from their finely stratified character and evidences of tranquil deposit, were laid down, not along the gradually retreating edge of a lake, but in the bottom, and at depths not very considerable. This being the case, the deposits give us the means of recognizing a surface—that of the lake bottom—which was at least proximately horizontal during the interglacial period at which they were formed. From Wolf Island to Coal Banks, the two points farthest apart at which the deposits were observed, is a distance of forty-five miles in a direct line, on a bearing of about S. 70° W. The height above the river of the deposits at the former locality is seventy feet, at the latter, one hundred and five feet, giving a slope eastward of 0·77 feet per mile in addition to that of the present river bed. The latter may be assumed as indicating that of the present surface of the country, as a whole.

"The elevation of the beds in the intermediate Drift-wood bend section is about ninety-six feet, but the locality is only about six miles westward on the same line, and the resulting slope per mile is 4·3 feet, in addition to that of the river, in the same easterly direction, a rate of fall locally much greater than that above determined for the whole distance.

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* See also Geology and Resources of the 49th Parallel, p. 264.

"The rate of fall of the Belly River, by its course, between Coal Banks and its mouth, is 6·8 feet to the mile, but on the line above defined (which is that of its general direction) between Wolf Island and Coal Bank, 12 feet to the mile. Adding the general slope previously ascertained for the intercalated beds, we find their eastward inclination to be 12·77 feet to the mile.

"The general eastward slope of the plains from the base of the mountains to that of the Laurentian region at Lake Winnipeg is about 5 feet to the mile, but the elevation increases more rapidly westward and in the region now considered; and if the intercalated beds referred to were again brought back to horizontality, the plains between the mouth of the Belly River, and Coal Banks would become nearly horizontal also.*

"Besides the effect of the glaciation of the country on its soils and general features, a further result of economic importance in connection with this period is *the distribution of gold.* Dr. Selwyn in 1874† expressed the belief, based on an examination of the country near Edmonton, that the gold found in the rivers of the Great Plains has been derived from the Laurentian and Huronian region to the east, and not from the Rocky Mountains. The facts met with in the district now reported on, conclusively prove the correctness of the above statement. In favorable spots on all the streams of which the banks and beds show abundance of Laurentian and Huronian Drift, fine gold may be obtained, while beyond the edge of this drift in the immediate vicinity of the mountains, I have never been able to detect a 'colour.'"

2. *Elephant Pipes in the Museum of Natural Sciences, Davenport, Iowa*, by CHARLES E. PUTNAM. 40 pp. 8vo, 1885. Davenport.—This address, by the President of the Davenport Academy of Natural Sciences, was called forth especially by expressions of disbelief with regard to accounts of the discovery of "elephant pipes" of soft sandstone and "inscribed tablets" in Indian Mounds of Iowa, published in the Proceedings of the Academy. Mr. Putnam makes the following statements with regard to the finding of these objects.

The discoveries in question are two elephant pipes and three inscribed tablets. Of the latter the first two were found in what is known as Mound No. 3, on the Cook farm, adjoining the city of Davenport. The principal discoverer was Rev. Jacob Gass, a Lutheran clergyman, then settled over a congregation in Davenport. In this exploration Mr. Gass was assisted by L. H. Willrodt and H. S. Stoltzenau, with five other persons who were accidentally present during the opening of the mound. The discovery was made on January 10th,1877. An exact and careful statement of the facts connected therewith was soon after prepared by Rev. Mr. Gass, and read at an early meeting of the Davenport Academy. It was published, and may be found in its "Proceedings."* Upon the announcement of the discovery, the officers and many members of the Academy were early on the ground to verify the statements made by the discoverers. The gentlemen engaged in the exploration are well known, and held in high esteem; their testimony as to all essential facts is clear and convincing, and the circumstances narrated seem to fully establish the genuineness of these relics. That their statement contains only facts all who know them will not question, and that the mound from which the relics were obtained had not been previously disturbed is sufficiently established by their testimony. The authenticity of this discovery must therefore be conceded by every fair-minded inquirer.

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* In the region west of the Missouri, the present inclined position of the Pliocene beds shows that since the time of their disposition that part of the region in the vicinity of the Rocky Mountains has been greatly elevated. It may well be that the eastward slope of the portion of the plains here treated of may have been produced as a result of the same great movement, and if so the facts above recorded would assign it a date subsequent to that of the glacial period.

† Report of Progress, 1873–74, p. 58.

The third inscribed tablet was found on January 30th, 1878, in Mound No. 11, in the group of mounds on Cook's farm, in the suburbs of Davenport, and in close proximity to the mound wherein the other tablets were discovered. That indefatigable explorer, Rev. J. Gass, was also present during these further researches, and had for his assistants John Hume and Charles E. Harrison, both members of the Academy, and well and favorably known in this community. The circumstances of this discovery, as narrated by Mr. Harrison, are published in the Proceedings of the Academy.† No suspicions whatever attach to this discovery, and the well-attested facts connected therewith establish beyond reasonable doubt, that, whether more or less ancient, the tablet was deposited at the making of the mound.

Of the elephant pipes in the museum of the Academy, one was discovered in March, 1880, in a mound on the farm of Mr. P. Hass, in Louisa County, Iowa, by Rev. A. Blumer, a Lutheran Clergyman from a neighboring city, and was by him donated to the Academy. Rev. J. Gass, Mr. F. Hass, and a number of workmen were present, assisting in the exploration. A detailed account of the finding, prepared by Rev. Mr. Blumer, is published in the Proceedings of the Academy.‡ From the social standing and high character of the principal discoverers, no question has been, or can be, successfully raised as to the authenticity of this discovery. The other elephant pipe was not "discovered" by Rev. J. Gass, but was obtained by him from a farmer in Louisa County, Iowa.§ This man found it while planting corn on his farm several years prior to that date, and attached no particular value to the relic, but had sometimes used it in smoking. A brief account of its finding is given in the Proceedings of the Academy. It will thus be perceived that there are no suspicious circumstances connected with either of these discoveries, but that the surrounding and well-authenticated facts seems to sufficiently establish the genuineness of these interesting relics.

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* Proceedings Davenport Academy of Natural Sciences, vol. ii, p. 96.

† Ibid, vol. ii, p. 221. Mr. Harrison is now Vice-President of the Academy.

‡ Ibid, vol. iii, p. 132.

§ Ibid, vol. iii, p. 349, note.

Mr. Duncan observes that "their authenticity established, archæologists will find in them strong corroborative testimony that man and the mastodon were contemporary on this continent."

The pamphlet closes with an appendix in which a figure is given of one of the elephant pipes. The form of the elephant and the large ears and trunk are unmistakable, but the tusks are wanting.

3. *The Mersey Tunnel;* by T. Mellard Reade, F.G.S.—All who are interested in the success of a great engineering work will be pleased to hear that the Mersey Tunnel is now completed under the river and arched in. This is cause for congratulation all round, and especially to Liverpool people, for it has been an undertaking of great boldness both in conception and execution.

Having ventured a prediction as regards the strata likely to be met with, in a paper "On the Buried Valley of the Mersey," published in the "Proceedings of the Liverpool Geological Society," as far back as 1872, I think it is well, now the work is secure beyond a doubt, to call attention to the actual facts. In my paper of 1872 I stated the grounds of my belief that, notwithstanding the prevailing opinion that a shelf of rock extends across from Seacombe Point to Prince's Dock, it would be found that there exists in the bed of the river between Liverpool and Birkenhead a "deep rock channel or gully filled with drift."

In a paper on the "Drift Beds of the Northwest of England," Part II (Quarterly Journal of the Geological Society, May, 1883), I restated this view; and in the columns of the Builder, February 4, 1882, I further called attention to and insisted upon it. I may may also add that my views were published in the face of two sections in my possession at the time (1872) which professed to give the actual surface configuration of the rocky bed of the river as ascertained by borings for the projected tunnels; one on the site of that now carried out, the other higher up the river, between the south end of the city and New Ferry, both of which showed a thick covering of rock over the tunnels the whole way across the river.

The actual facts are these. The tunnel works have shown that the rocky bed of the river at its deepest point is, some 300 yards from the Liverpool side, deeply buried in drift. About 100 yards of this gully or pre-glacial bed have been intersected by the upper part of the tunnel. Before this part was finally arched up I had permission from the engineers to inspect it, which I did in company with my friend, Mr. Frank Archer, of the firm of Messrs. Gill & Archer, solicitors to the company, who have done so much to insure the success of the undertaking. Mr. Archer, having a good knowledge of geology, has always felt the greatest interest in the geological aspects of the tunnel works. We found the upper part of the tunnel section was in stiff, hard, bowlder clay resting, excepting in one place where there was a thin patch of yellow sand, upon the hard surface of the homogeneous Triassic rock. There was no doubt of the nature of the strata; the clay was of the true glacial-marine type, and numerous bowlders of granite, trappean rocks, and greywacke were strewn about,—specimens of these are now in Mr. Archer's possession. All that I saw were rounded, and not striated, having the character usually possessed by the lower beds of the low-level bowlder clay as described in the account of the Atlantic Dock excavations.

Liverpool, December 5, 1884.

4. *Notes respecting Metamorphism;* by J. J. STEVENSON (Proc. Amer. Phil. Soc., Dec., 1884).—Professor Stevenson mentions cases where upturned and folded beds have become metamorphic and others in similar condition remain unchanged. He speaks of Lower Silurian shales (Knox group) in Russell County, Va., very much twisted, and still unaltered; of the red Medina sandstone thrown into close folds on the east side of Evitt's Mountain, in Bedford County, Pa., for a distance of more than 1000 feet, without any appearance of change in the rock; and the Hudson and Utica shales, a little way off to the east, turned up on edge, and still not showing slaty cleavage. Other cases are mentioned where sandstones are turned to quartzytes; and in one, in the Elk Range, Central Colorado, the extent of change increases with the distance from the median line of the fold. Cases are mentioned, also, of great change, and of none or very little, at contacts with eruptive rocks. He refers to the coal changed to coke in the Trinidad coal field of Colorado and New Mexico against intruded sheets of basalt or dikes of trachyte; but, on the north slope of the Placer mountains, a narrow dike of basalt cuts through the Laramie beds, and along an exposure of 38 feet "no effect whatever has been produced on the coal even at the line of contact."

5. *A Reprint of Geological Reports and other papers on the Geology of the Virginias;* by the late WILLIAM B. ROGERS, LL.D., etc., Director of the Geological Survey of Virginia from 1835 to 1841; President of the National Academy of Sciences. 832 pp. 8vo, with cuts, plates, and a large geological map. New York, 1884: D. Appleton & Co.—Among the State geological surveys which were carried forward before 1842 no one was of greater importance than that of Virginia under the direction of Professor William B. Rogers. Begun in 1835, it was vigorously prosecuted to the close of the year 1841, when, although the work over the great State was far from complete, further appropriations were withheld with no provision even for a final report. The results obtained were of the highest importance as regards the mineral wealth of Virginia and American Geology, and of great interest to general geological science through the developments made with respect to the structure and origin of the Appalachians, its coal fields, and other subjects illustrated; but, unfortunately, the annual reports were to be found in very few libraries.

Mrs. William B. Rogers has conferred a great benefit on the science of the country by generously editing and issuing a volume containing these reports together with other later papers by their author on Virginia geology. They are reprinted just as they were originally published, with only such changes as Professor Rogers had himself made. But to them are added numerous colored stratigraphical sections—ninety in all—on seven large sheets which had never before appeared. These sections have special value on account of their exhibitions of the flexures of the Appalachian rocks, the positions of the coal strata, and various other stratigraphical points. To the report is added also a small colored geological map of the Virginias—then one Virginia—made from a manuscript map by Professor Rogers, but with some changes and additions to bring the map up to date. This small map, as the preface states, is to be followed before long, "after certain topographical surveys are completed," by a larger geological map.

The volume contains descriptions of fossil plants of the Mesozoic Red Sandstone, referred by Professor Rogers to the Oölite, with figures of three species (*Zamites obtusifolius*, *Tæniopteris magnifolia* and *Lycopodites uncifolius*) and five plates of shells of the Miocene Tertiary of Virginia.

The last paper of the volume is Professor Rogers's last communication to geological science—an account of an infusorial deposit which was passed through in an artesian boring at Fort Monroe at a depth between 558 and 570 feet below the surface. A section of the beds intersected is given; in its explanations the deposit is called Miocene, but the text makes it Eocene. The specimen was put into the hands of Mr. Samuel Wells, in 1875 for examination, and he reported that out of the 40 species found 29 were identical with those of the Richmond infusorial stratum which Professor Rogers had described fifty years before.

The work is a large one—832 pages in small type—and contains thereby a great amount of matter important to geological science, and much also on the mineral products of the State.

6. *Fulgurites in the High Alps.*—M. Brun describes in a recent number of the Archives des Sciences, etc., of Geneva, the discovery of fulgurites or lightning tubes by himself and others upon a number of mountain summits in the Alps, at elevations varying from 3,348 to above 4,000 meters. The observations are interesting in connection with the recent description by Diller of fulgurites from Mt. Thielson in Oregon (see this Journal xxviii, 252).

The fulgurites are found on the highest point of the mountain, or in one case on a ridge a few meters below the summit. The fused portion presents itself under various aspects, sometimes as a collection of glassy beads a fifth of a millimeter in thickness and covering several square centimeters of the rock; or again in hemispherical forms several millimeters in diameter and hollow within. Sometimes vitrified sinuous lines 10 to 12 centimeters in length and coming to a common center are observed. In another case the walls of a small depression, 8^{mm} in diameter, in the center of the surface of a block of gneiss were completely vitrified, in still another a pebble which projected from a pile of stones had been perforated as if by a bullet and the sides of the hole completely fused. The thickness of the glass formed is never more than ¼ to 1 millimeter, and the fused surface has no great extent. The mass of fused matter consequently does not exceed 0·1 to 0·5 grams; one fulgurite weighed only 0·122 grams. The glass formed is that which would naturally result from the fusion of the adjacent minerals. It is brilliant, with mammillary surface, conchoidal fracture, varying in color and transparency. The fulgurites on the Rympfischhorn were black, as was to be expected since the rock is rich in actinolite; others from the Ruinette were pale brown, the rock being a chloritic gneiss with feldspar predominating. Examined with the microscope the fulgurite shows the presence of numerous cavities, caused by the vapor of the water which moistened the rock surface at the moment of fusion; there are also numerous inclusions with regular form in the homogeneous vitreous mass, which are fragments of the minerals torn off but not fused. The glass exerts no action on polarized light. An analysis of a fulgurite from Mont Blanc de Seillon on the gneiss gave the following results:—

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Alkalies
65·73	19·59	5·57	3·03	1·71	[4·37] = 100

The analysis proves that the iron of the chlorite has been oxidized as was to be inferred from the dark color of the glass. M. Brun states that thus far fulgurites have been observed upon nine of the high peaks of the Alps, and adds that many more will doubtless be discovered if attention is directed to the subject.

7. *Paleontology of the Eureka District;* by CHARLES D. WALCOTT, U. S. Geological Survey, J. W. Powell, Director. 298 pp. 4to, with 24 plates.—Some of the results of Mr. Walcott's study of the Eureka fossils (his personal collections) are mentioned in a notice of the second Annual Report of the Geological Survey, in this Journal (xxvii, 65, 1884). In the volume now published the species are described in full, with a statement of such paleontological conclusions as the present state of the facts appeared to warrant. The species belong to the Cambrian and Lower Silurian, Devonian and Carboniferous. The Upper Silurian is not represented, or only by two fossils, *Halysites catenulatus* and a *Zaphrentis.*

The report makes out for the region over 60 Cambrian species, two-thirds of them Trilobites, and over 100 Silurian species, nearly half of which are new.

The number of species and genera is sufficient to enable the author to establish the important fact that the transition as regards life from the Cambrian to the Lower Silurian is gradual, and to make out approximate equivalency with the Wisconsin and New York formations. Between the Devonian of the region and that of eastern localities he finds parallelisms, yet with some cases of a reversal of the previously known order of succession, and of wider stratigraphical range; as in the occurrence of the Tully limestone (Hamilton) species, *Orthis Tulliensis*, at the summit of the Devonian limestone, and of the Chemung species *Orthis impressa* associated with eastern Upper Helderberg species. There is also a commingling of Upper Devonian species with the Lower Carboniferous fauna.

An interesting discovery is that of Pulmoniferous mollusks of the genera Physa and Zaptychius in the Subcarboniferous.

8. *The Occidental Alps.*—M. Lory has given the results of his explorations in this region in the Bulletin of the Geological Society of France, ix, 652 (1881). He states that no break exists between the crystalline schists, gneiss, mica schists, hornblende schists, of the "terrain primitive" and the Silurian beds to the eastward, and at Outer Rhône, in the Valais, the distinction between them is made out with difficulty. This author divides the Alps into a sub-Alpine and four Alpine zones, limited by faults. Of these four, the *first*, or that of Mt. Blanc (with the Aiguilles Rouges, etc.), and the *fourth*, or that of Monte Rosa, contain crystalline rocks, which are of rare occurrence over the intermediate region. The crystalline schists of the *fourth* zone are, beginning with the upper, sericite schist, chlorite schist with alternations of hornblendic schist, mica schists with alternations of cipolin and granular limestones, well stratified granitoid gneiss. In the first zone the coal formation is sometimes conformable with the crystalline schists and sometimes not. The greatest displacements in the region occur between the Carboniferous beds and the Trias—or the Lias where the Trias is absent. The protogine of Mont Blanc is in normal superposition over the mica schists, and its "en eventail" structure is not due to a central anticlinal fold, but simply to a synclinal fold of the upper series of crystalline schists. The great faults separating the four zones existed already in the Carboniferous era. Another fault, that of Grésivaudan, separates the first Alpine chain from the Subalpine, and it was slowly formed between the Upper Oölite (the Callovian) and the Chalk, and produced a displacement of 2000 meters.—*Archives des Sci. Phys. et Nat.*, xiii, March 15, 1885.

9. *Communicações da Secção dos Trabalhos Geologicos de Portugal.* Tom. I, fasc. 1, pp. 1–168, 8vo., Lisbon, 1885.—The Geological Commission of Portugal has commenced the publication of an octavo series, the successive numbers of which are to contain the minor works of the survey and which are to be published as often as the articles are sufficient to form a fascicule. Part I of the first volume now issued contains ten papers, among which may be noted, one by A. Ben-Saude on the optical anomalies of isometric crystals, a subject to which he has already made important contributions; another by Macpherson on the ophites and teschenites of Portugal; several by P. Choffat, one of these is on the age of the granite of Cintra. This granite occurs in veins in the strata belonging to the lower parts of the Malm,

and is consequently more recent than that; from a survey of all the facts the author concludes that the granite belongs either to the upper Cretaceous or to the Eocene, but as it is impossible to decide between these he regards the expression post-Cenomanien granite, as more correct than tertiary granite.

10. *Rhinoceros and Hippotherium from Florida.*—Dr. LEIDY describes in the Proceedings of the Philadelphia Academy of Natural Sciences for 1885, p. 32, two teeth, one belonging to an extinct Rhinoceros, which he names *R. proterus* (whether of the subgenus *Aceratium*, *Aphelops* or others is not determinable without other parts of the skeleton); the other, to the genus *Hippotherium* (which includes three-toed horses from the Miocene and later Tertiary), naming it *H. ingenuum*.

The specimens occur, with fragments of a crocodile, a carnivore about the size of a fox, and a lama, in a deposit overlying the Vicksburg limestone of Eocene age; but of what precise period later than Eocene is doubtful.

A species, named *Hippotherium venustum* in Holmes's Pliocene fossils (1860, 105, pl. xvi), and earlier *Hipparion venustum* (Proc. Philad. Acad. Nat. Sci., 1853, p. 241), was from the Ashley River phosphate beds of South Carolina.

11. *Das Antlitz der Erde*, *von* EDUARD SUESS, Zweite Abtheilung, pp. 311 to 778, 1885, Prag (F. Tempsky), and Leipzig (G. Freytag).—The first portion of Professor Suess's most interesting and suggestive monograph was noticed in this Journal a little more than a year ago (vol. xxvii, 151). The general design of the whole work was there given, and the relation of the successive parts into which the subject had been divided. The present part completes the first volume. It is devoted to a discussion of the mountain systems of the earth, the first three chapters of which subject were contained in part I. The Mediterranean, the deserts of Northern Africa, the mountains of India, the relation of the Alps to the Asiatic mountains, the mountains of the American Continent, are some of the subjects which are discussed. The completion of the work will be awaited with interest.

12. *Studies of some Japanese rocks.*—Dr. BUNDJIRO KOTÔ, of Tsu-wa-no, Iwami, Japan, has published, as his inaugural dissertation at Leipzig, the results of a careful study of a series of Japanese rocks—pyroxene andesite, basalt, diabase, granite, diorite, porphyrite. Among other points of interest he describes the pyroxene of the andesite as being in part pleochroic, in part not, though both are monoclinic, and the author concludes belong to the same species. An analysis of the pleochroic augite, separated by the Thoulet solution, afforded

SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	MnO
53·26	4·01	3·42	14·07	10·15	14·65	tr = 99·56

These andesites also contain sparingly hornblende which is altered on the margins to pyroxene.

13. *American Fossil Cockroaches.*—Prof. S. H. SCUDDER describes new fossil cockroaches in the Proceedings of the Philadel-

phia Academy of Natural Science, 1885, p. 34—two from the Carboniferous deposits of Mazon Creek, Illinois, for which two new genera *Promylacris* and *Paromylacris* are instituted; and eight from the Triassic of Fairplay, Colorado, of the genera *Spiloblattina* (new), *Oryctoblattina*, *Petrablattina* and *Poroblattina* (new).

14. *Silurian fossil Cockroach from Jurques in Northwestern France.*—M. C. BRONGNIART has announced the discovery of the wing of a cockroach, showing most of its nervures, in a piece of Middle Silurian Sandstone belonging to De Verneuil's collection. The wing is 25 mm. long. He proposes for it the name *Palæoblattina Douvillei.* Its geological position makes it older than the Scotch and Swedish scorpions.—*C. R.*, Dec. 29, 1884; *Ann. Mag. Nat. Hist.*, xv, 355, April, 1885.

15. *Geology of Southern Kansas.*—A paper in the Bulletin of the Washburn College Laboratory, Topeka, Kansas (vol. i, No. 3, 1885), by the editor, describes the geology of Southern Kansas. It is stated that the Dakota Group (of the Cretaceous) commences at Milan and is the main country rock through Harper county to Medicine Lodge, but is partly overlaid by Tertiary. Its most remarkable feature is its stratum of massive gypsum, 12 to 20 feet thick, which is continuous over an area of 500 square miles. It occurs in the Dakota beds, but to the west is mostly in the overlying Benton group, and later Cretaceous. This gypsum bed is distinct from another Kansas bed in the Permo-Carboniferous.

16. *Illustrations of the Fauna of the St. John Group, continued: on the Conocoryphea, with further remarks on Paradoxides,* by S. F. MATTHEWS. Trans. Roy. Soc. Canada, 1884, p. 99.—Mr. Matthews in his concluding remarks observes that the St. John beds are probably older than the other Cambrian areas of the Atlantic border, the Newfoundland and the eastern Massachusetts, and are best comparable in fauna with the oldest of the British Cambrian.

17. *Mineralogical Notes.*—Professor G. VOM RATH in a recent memoir (Bonn, 1885), describes and figures a number of the remarkable quartz crystals from Alexander and Burke counties, North Carolina, which had been placed in his hands for study by several American mineralogists. Of the North Carolina crystals in general, he says that in crystallographic interest they surpass the specimens of all other known localities of this most remarkable of minerals. They seem, he says, to embrace all the interesting features which have been described in crystals from other places. The general feature of the crystals is the occurrence of acute rhombohedrons, especially the rhombohedron 3R, with too the upper trapezohedral planes, particularly $-\frac{3}{2}-\frac{3}{2}$. The twin crystals also offer many peculiarities. Several new planes are given by vom Rath, for which, and other points of detail, however, reference must be made to the original paper.

The same pamphlet contains the description of a remarkable crystal of stephanite from Mexico, tridymite in andesite from Krakatan; colemanite from California. (Compare this Journal, xxix, p. 34.)

18. *Bournonite; Cuprite.*—Mr. H. A. MIERS of the British Museum has recently published in the Mineralogical Magazine an exhaustive monograph on the crystallography of bournonite. To the accepted list of 50 forms, 29 well established new ones are added and 21 others which need confirmation. A table of upwards of 1000 angles gives all those which are important for the species.

The same author has observed upon Cornish crystals of cuprite planes of the hexoctahedron $\frac{3}{2}$–$\frac{9}{8}$ (986) developed in accordance with trapezohedral or gyroidal hemihedrism, a kind of hemihedrism long recognized as possible, but never before observed on natural crystals, and only once on artificial crystals (sal ammoniac).

19. *Lehrbuch der Mineralogie;* von Dr. GUSTAV TSCHERMAK, Zweite verbesserte Auflage. 597 pp. with 756 original figures and 2 colored plates. Vienna, 1885 (Alfred Hölder).—The first edition of Professor Tschermak's admirable Text-book of Mineralogy has already been noticed in these pages. Constant use of the book through the past year has served to confirm the first impression as to its value, which has been increased by the changes introduced into this new edition. It is remarkably clear and thorough in the theoretical portion and much originality both in matter and in manner of presentation. The descriptions of species are brief, sometimes almost too much so, but they are given in a form that renders them more than usually attractive to the average student. The large numbers of figures introduced are all from original drawings and in execution leave nothing to be desired.

20. *Fairfieldite from Bavaria.*—The rare mineral fairfieldite, hitherto known only from Branchville, Fairfield County, Conn., (see Brush and Dana, this Journal, xvii, 359), has been identified by Sandberger, at Rabenstein, Bavaria. Some years ago (Jahrb. Min., 1879, 370), he gave the provisional name leucomanganite to a supposed new phosphate from that locality. The discovery of additional material has enabled him to prove that this mineral is identical with fairfieldite, and the other name is accordingly withdrawn.

21. *Informe sobra las Especies Minerales del Estado de Jalisco per* CARLOS F. DE LANDERO. 41 pp. 8vo. Guadalajara, 1884.—This little pamphlet contains brief statements of the numerous minerals found in the State of Jalisco, Mexico. Similar accounts for the other Mexican States are to be desired.

22. *Smaltite from Colorado.*—In the analysis of smaltite on page 380 of volume xxiii, the percentage of iron should read 15·99 instead of 11·99 as there given.

III. ZOOLOGY.

1. *Elementary Text-Book of Zoology;* by Dr. C. CLAUS, translated and edited by ADAM SEDGWICK, with the assistance of F. S. HEATHCOTE. 2 vols. 8vo, with numerous wood cuts. MACMILLAN & Co., New York, 1885.—This is an American edition of the English translation of the already well-known standard German text-book of Professor Claus. The editor has adhered very closely indeed to the original German text and has made very few additions, which are enclosed in brackets. In some respects a mere translation has its advantages, but as a current text-book of a science so eminently progressive, it is to be regretted that the able translator has not thought it best to make more numerous additions, in the form of foot-notes or otherwise, so as to bring the statements more nearly down to the actual state of the science in the year 1884, the date of the preface to the English edition. As a general thing most of the important discoveries made within the past five or six years are not referred to, and in other respects the book is not brought down to date. Even many of the important recent discoveries and investigations made in England are not in any way mentioned, and far less seldom is anything of American origin alluded to. In fact, the book, though in good English, is practically a German book still, and the books and authors quoted, or referred to as authorities in the lists of books to be consulted, are nearly all German, even when of less importance and value than other works in English and French, which are not mentioned. This is a peculiarity that we naturally expect in a German book, but it might easily have been remedied, to a great extent, by the editor, if he had chosen to add references to a considerable number of the more important books printed outside of Germany, and especially in the English language.

The appearance of the English translation will undoubtedly give this book a far wider circulation in England and America than it has hitherto had, and as a reference book for somewhat advanced students, it is, perhaps, unexcelled, even with the imperfections referred to, which are largely due to the fact that the book was written from a German point of view, and for German students, and has already been published some years in Germany.

About 180 pages of the first volume are devoted to the general facts of comparative anatomy and physiology, histology, embryology, reproduction of various kinds, evolution, etc. This part of the book will be of great interest and use to many who are not specialists in zoology, but who desire a general knowledge of the modern status of zoological biology. Chapter v, which treats briefly of evolution, Darwinism, etc., and the evidences for and against these theories, will be of more general interest, perhaps, than any other chapter.

The remainder of the two volumes is mainly devoted to systematic zoology, which is, in general, treated with great ability and skill.

As a matter of course, the classification adopted is capable of being criticised in many respects. But upon this subject zoologists are still very far from agreeing, so that every writer may, if he chooses, hold his own views of the classification of many portions of the animal kingdom. The first volume includes the Protozoa, Cœlenterata, Echinodermata, Vermes and Arthropoda. The rest of the groups are included in vol. ii.

The Arthropoda, and especially the Crustacea, are very fully treated in the first volume, while the greater part of the second is devoted to the Vertebrata (230 pages). The illustrations are very numerous (706) and are, for the most part, well selected and carefully engraved. A. E. V.

2. *Presence of eyes in the shells of certain Chitonidæ.*—Mr. H. N. **Moseley**, in the Quarterly Journal of Microscopical Science for January, 1885, states his discovery of eyes in the shell of certain Chitons, and describes and figures their microscopic structure and method of formation. They occur on the outer surfaces of the shells of some species of these mollusks, and are about $\frac{1}{175}$th inch in mean diameter. In *Schizochiton incisus*, the diameter is $\frac{1}{35}$th inch; the anterior shell has six rows of eyes and the posterior the same, the middle shells, two rows, with one exception, in which there are three. In other species the arrangement is different. In *Tonicia marmorata* the eyes of the anterior shell, in one specimen, lie in 34 radial lines, each line containing about 18 eyes.

The eyes have a convex cornea, a lens, and around the cornea a narrow zone of dark pigment which is the margin of the pigmented eye-capsule. Through the center of each cornea is seen a small circular area somewhat darker than the aperture of the pupil, but showing a brilliant spot of totally reflected light due to the lens. The soft structures of the eye lie in a more or less pear-shaped chamber, excavated in the surface of the tegmentum. The eye is sometimes prominent, and sometimes sunk in a shallow pit. Mr. Moseley figures the ramifications of soft tissue, which pass to the eyes and describes some of the branches as terminating in points, the papilliform bodies of Van Beneden, that probably are, according to Mr. Moseley, organs of touch, and are called by him megalæsthetes. The eyes are evidently to be regarded as modifications of megalæsthetes.

The forms of the Chitonidæ having well developed eyes appear to be mostly non-European.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Temperature for March.*—The Bulletin of the New England Meterological Society for March, 1885, contains the following statements in regard to the temperature during that month: "The month has been characterized by a greater amount of fair weather and less wind than is usual in March. Two features especially distinguish the month from the corresponding month

of former years, viz.: the small precipitation and the low temperature. The latter condition, added to the similar low temperatures of February and the last half of January, closes a season of remarkable severity. At Worcester, Mass., the continued cold is unexampled in the forty-seven years of continued observation, and it is probable that a similar result would be found at other stations, were the records examined. The observations at Gardiner, Me., Cambridge and Worcester, Mass., Providence, R. I., and New Haven, Conn., which cover a long succession of years, show that the average temperature of the three months, January, February, and March, 1885, was 5·2° below the average, and of the four months, December, 1884,—March, 1885, 3·3° below the average. The month closed with warmer weather, but the frost in the ground in southern New England extended to a depth of two or three feet, and good sleighing continued in the northern section.

"The unusually low average temperature of the month was the result of steady cold with but few single records of great severity. The temperature reached zero, however, at nearly all stations, as will be seen from Table II. The month was the coldest March on record at Gardiner, Me., Burlington, Vt., and Worcester, Mass., at which continuous records of nearly half a century have been consulted.

2. *Scientific Papers and Addresses of* GEORGE ROLLESTON, M.D., F.R.S., Linacre Professor of Anatomy and Physiology and Fellow of Merton College, Oxford, arranged and edited by William Turner, M.B., F.R.S., Prof. of Med. and Anat. Univ. Edinburgh, with a biographical sketch by Edward B. Tylor, F.R.S., Keeper of the Museum, Oxford. 2 vols., 948 pp., 8vo, with portrait, plates and wood-cuts. 1884, Oxford, (Clarendon Press, Macmillan & Co.).—Dr. Rolleston was a scholar of vigorous, independent, ever active mind, of wide range of knowledge, of brilliant and eloquent speech, and judiciously liberal in politics and everything else; a man who wrote "there is no subject so pleasing, and none so ennobling as the triumph of will over interest and the victory of conscience over expediency," and practiced accordingly. After a few years of work in the medical profession—nine months of it at the English hospital at Smyrna during the Crimean war—he was elected professor at Oxford in 1860. He died in 1881 in his 52d year. His scientific papers in the two volumes now published related to subjects in physiology; brain-anatomy; human and simian brains; craniology of the British Barrows or Bushmen, etc., excavations in ancient cemeteries in England with descriptions of skeletons and other archæological facts; also on subjects in zoology; with addresses on the modifications of aspects of organic nature produced by man; biological training and studies; the relative value of classical and scientific training; the earth-closet system; typhoid and enteric fever in Indian gaols, and on the relations of that disease and the cholera to the dry-earth system of conservancy; and other topics.

3. *Upon the formation of a deaf variety of the Human Race;* by **Alexander Graham Bell.** Paper presented to the National Academy of Sciences at New Haven, November 13, 1883. 86 pp. 4to.—Mr. Bell has here brought to bear his scientific precision and exact methods of investigation on a question of great importance to society. He concludes that the tendency to intermarriage of deaf mutes, from their congregation in asylums and being taught by signs only intelligible among themselves, promotes intermarriages and the increase in the number of deaf mutes, and urges that the schools for them should be small, and that instruction in articulation and speech-reading should take the place of signs.

4. *Prehistoric Fishing in Europe and North America;* by **Charles Rau.** 342 pp. 4to, with numerous cuts. Smithsonian Contributions to Knowledge, No. 509.—This volume contains a thorough report, with very numerous figures, of all that has been published on the implements, materials, boats, etc., used in fishing by prehistoric man, all stone pipes and other carvings, and pictures representing fishes and other animals of the water; and much about the modes of fishing, the shell-heaps, and other ethnological facts connected with the seashore Indians. It is full of matter of archæological value, all of which is presented in excellent style, with the best of woodcut illustrations representing the various objects described.

5. *Dictionary of Altitudes in the United States;* compiled by **Henry Gannett**, U. S. Geological Survey. 326 pp. 8vo.—A valuable volume of reference. It is essentially a new and enlarged edition of the work of Mr. Gannett published by the U. S. Geological Survey of the Territories in successive editions of the years 1873, 1875 and 1877.

Anales de la Oficina Meteorologia Argentina par du Director Benjamin A. Gould. Vol. iv, 600 pp. 4to. Cordoba, 1884.

The Lenâpe and their Legends, with the complete text and symbols of the Walam Olum, a new translation and an enquiry into its authenticity; by Daniel G. Brinton, A.M., M.D. 262 pp. 8vo. Brinton's Library of Aboriginal American Literature, No. V. Philadelphia. 1885.

The deflective effect of the earth's rotation; by W. M. **Davis.** Reprinted from the American Meteorological Journal. Vol. 1, No. 12. 1885. (W. H. Burr Publishing Co., Detroit, Mich.) A brief and simple exposition of the subject.

The osteology of Amia calva, by R. W. Shufeldt, Rep. Comm. Fish and Fisheries for 1883. 90 pp. 8vo, with 14 plates.

Die Fauna des Iberger Kalkes, von J. M. Clarke. 94 pp. 8vo, with three plates of figures of fossils. Stuttgart, 1884. (N. Jahrb. f. Min. Geol. u. Pal., 1884).

Asteroidea, ved D. C. Danielssen og Johan Koren. 120 pp. large 4to, with 15 plates and 1 map. Den Norske Nordhavs-Expeditionen, 1876–1878. XI. Christiania, 1884.

Fourteenth Annual Report on the Geological and Natural History of Indiana for 1884. John Collett, State Geologist. Part 1st, Geology and Natural History, 122 pp. 8vo, with a colored geological map of the State; Part 2d, on the Post-Pliocene Vertebrates of Indiana, by Prof. E. D. Cope and James Wortman. 62 pp. 8vo, with 6 plates Indianapolis, 1884.

Bulletin of the U. S. National Museum; No. 27, Descriptive Catalogues Constituting a Report upon the Exhibit of the Fisheries and Fish-culture of the United States of America, made at the London Fisheries Exhibition. 1883; prepared under the direction of G. Browne Goode, U. S. Commissioner and a staff of associates. 1280 pp. 8vo. 1884. Washington.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. LIV.—*Notes on American Earthquakes, No.* 14; by C. G. ROCKWOOD, JR., Princeton, N. J.

IN this article, as in former ones of the series, I give a summary of the information which has come into my hands in regard to earthquakes which occurred during the preceding year in North or South America and the adjacent waters. The information has been gathered from various sources, largely from the Monthly Weather Review of the U. S. Signal Service, and from current newspapers; but I have also been fortunate in receiving a greater number than usual of manuscript reports, mostly relating to the shock of Aug. 10. For many of these my thanks are due to Cleveland Abbé of the Signal Service, and especially to W. M. Davis of Harvard College, who kindly put into my hands a large amount of matter, both manuscript and printed, which he had collected. The persons, whose letters to these two gentlemen I am reaping the benefit of, are too numerous to be mentioned here by name, but putting their contributions with my own collection, I find that I have at command about one hundred and fifty direct manuscript reports on the earthquake of Aug. 10, besides a very large amount of newspaper cuttings. For other reports I am, as heretofore, indebted to J. M. Batchelder of Cambridge, Mass., and to Charles Carpmael of Toronto, Superintendent of the Canadian Meteorological Service.

As in former notes, when a shock is recorded on the authority of a single report, the source of the information is indicated, and a few items, which were regarded as somewhat uncertain, are printed in smaller type. The division of the day into twenty-four hours is again employed.

An attempt has also been made in these notes to distinguish the shocks according to the degree of intensity. For that purpose a scale was provisionally adopted, with reference to which the adjective indicating intensity was selected, this selection being guided, whenever possible, by the statements of the phenomena observed rather than by the mental impression of the observer. Thus an earthquake called by the newspapers "severe" may perhaps be found characterized here as "light" because only causing the phenomena which mark that degree. The scale employed is as follows:

I. *Very light:*—Noticed by a few persons but not generally felt.

II. *Light:*—Felt by the majority of persons, rattling windows and crockery.

III. *Moderate:*—Sufficient to set suspended objects, as chandeliers, etc., swinging, or to overthrow light objects favorably placed.

IV. *Strong:*—Sufficient to crack the plaster in houses or to throw down bricks from chimneys.

V. *Severe:*—Overthrowing chimneys or walls and injuring some buildings.

VI. *Destructive:*—Causing general destruction of buildings, etc.

This scale is adopted for the purposes of the present article, but it is quite probable that considerations of uniformity with European observers may lead to the use of the Rossi-Forel Scale in future papers.

1884.

Jan. 3.—At 20^h 40^m a *light* shock occurred at Portland, Oregon; duration about two seconds; vibration southeast to northwest.—*U. S. Weath. Rev.*

Jan. 4.—At 11^h 56^m a *very light* shock at Los Angeles, California.—*U. S. Weath. Rev.*

Jan. 14.—At Montevideo, Uruguay, a little after 7^h 30^m the sea suddenly fell so that bathers were able to reach bottom where before there had been a depth of three metres. Immediately a wave, coming from the south-southwest, rolled upon the shore, raising the water about 1.50^m above its mean level. The phenomenon was confined to the immediate vicinity of Montevideo, not being noticed at Buenos Ayres on the opposite side of the estuary.—*Comptes Rendus*, Feb., 1884.

Jan. 18.—At 2^h a *moderate* earthquake occurred at Contoocook, New Hampshire, and vicinity.

Jan. 18.—At about 8^h two *light* shocks were felt on the southern coast of North Carolina. They were reported from Wilmington, New River Inlet, Fort Macon, and Beaufort, and ten miles east of Newberne, and also along the railroad connecting Newberne and Beaufort. They were sufficient to rattle windows and crockery. At Fort Macon a rumbling sound was heard, the duration was stated as three or four seconds, and the direction southwest to northeast.

Jan. 25.—Assistant George Davidson of the U. S. Coast Survey reported from San Francisco that at 19^h 24^m, "Earthquake waves were indicated by the levels of the astronomical instruments of the observatory. The amplitude of each vibration was three seconds of arc in six seconds of time and they continued for twenty minutes."

Jan. 27.—At 23^h 30^m a *moderate* earthquake occurred in Humboldt County, Cal. Two shocks were felt, the first at the time above stated, the second, a very light one, about five minutes later. They were preceded and followed by a roaring sound, and were reported from Eureka, Hydesville, and Cape Mendocino. At the latter place the first shock was sufficient to shake buildings perceptibly and to displace light articles. The direction was variously stated.

Jan. 29.—Three distinct *light* shocks at Rothesay, nine miles from St. Johns, N. B. The hour not stated.—*N. Y. Times.*

Feb. 15.—About 6^h a *very light* shock at Caledonia, Missouri, reported by R. F. Chew in the Saint Louis "Globe Democrat," Feb. 20, '84.

Feb. 16.—At 9^h a *very light* earthquake at Point des Monts, Quebec.—*Canadian Meteorol. Serv.*

March 2.—At 10^h 20^m a *moderate* shock in Orchilla Harbor, in the Caribbean Sea, and another lighter one at 4^h on March 4 at the same place; reported by Captain Holt of the ship "David Stewart."—*J. M. B.*

March 15.—At 3^h 7^m a *very light* shock at San Francisco, Cal., preceded by a loud rumbling noise.—*N. Y. Times.*

March 17.—At 14^h a *light* shock at North Platte, Nebraska.—*U. S. Weath. Rev.*

March 18.—Between 13^h 30^m and 13^h 45^m a *moderate* earthquake occurred in Southeastern Newfoundland. It extended from St. John, where it was only slightly felt, northwestward to Trinity, a distance of about sixty-five miles, being reported in the intervening country from Hearts Content, Harbor Grace, Roberts, Brigus Bay, and Holyrood. The direction was north to south.

March 25.—At 16^h 40^m a *severe* earthquake shock occurred at San Francisco, Cal., and vicinity, followed by a second somewhat lighter shock at 17^h 17^m. It was felt along the coast from Santa Cruz to Petaluma, a distance of about a hundred miles. The first shock lasted about five seconds, the other about two seconds. The direction was north and south. In San Francisco some houses were seriously injured, the walls being cracked so as to render them unsafe. It was severely felt in Oakland and Berkeley on the east side of San Francisco Bay.

March 29.—In the evening a *light* shock reported in Accomac County, Virginia. —*N. Y. Times.*

March 31.—At 5^h a *light* shock was felt at Milledgeville, Georgia.—*U. S. Weath. Rev.*

March 31.—At 13^h three *very light* shocks reported by J. W. Hammit at College Hill, Hamilton County, Ohio.—*U. S. Weath. Rev.*

April 6.—At 6^h 20^m a *very light* shock felt at Eureka and Hydesville, Humboldt County, Cal.

April 8 and 11.—*Very light* shocks in the morning at Eureka, Cal.—*U. S. Weath. Rev.*

April 11.—At 14^h 10^m a *moderate* shock at Carson City and Virginia City, Nevada; duration three seconds; vibration northwest to southeast.

April 17.—At 21^h 10^m a *light* shock at Oakland, Cal., accompanied by a rumbling noise; vibration northwest to southeast.—*U. S. Weath. Rev.*

April 20.—At 11^h 30^m a *very light* shock at Oakland, Cal.—*U. S. Weath. Rev.*

April 21.—At 9^h, the schooner "M. A. Nutter," when in lat. 21° 6′ N., long. 61° 44′ W. "was shaken from stem to stern by the shock of an earthquake, apparently from the westward." The position given is in deep water (about 3000 fathoms), about 200 miles northeast of Sombrero, Windward Islands.

April 30.—At 6^h 46^m, at Ogreeta, Cherokee County, North Carolina, a low rumbling sound of earthquake was heard, apparently from the north. No tremor was reported.—*U. S. Weath. Rev.*

June 6.—At 1^h two *strong* shocks were felt at Red Bluff, California, each of about one second's duration and with an interval of three or four seconds. The shock caused the wall of a brick building to crack. The direction was east to west.

June 12.—At 8^h 43^m a *strong* shock is reported by Capt. C. F. Swan to have been felt on the ship "City of Brooklyn" when in lat. 40° 24′ N., long. 125° 50′ W., being in the Pacific Ocean, about 75 miles west of Cape Mendocino, Cal. It "caused the vessel to shake as though she had struck a reef."

June 16.—At 10^h 48^m a shock was felt at Los Angeles, Cal., vibrations north to south; duration about two seconds.—*U. S. Weath. Rev.*

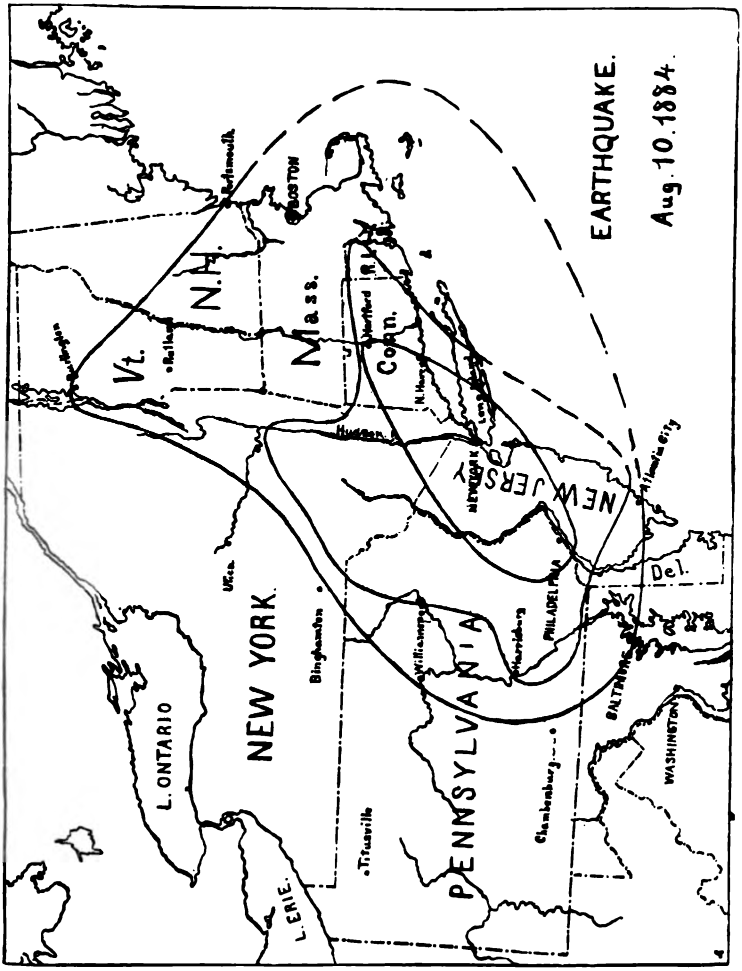
July 15.—About daylight a *very light* shock reported at San Francisco, Cal.; vibration east to west.—*U. S. Weath. Rev.*

Aug. 4.—About 1^h three *very light* shocks at Santa Barbara, Cal. A very light shock also on the night of the 2d–3d.—*U. S. Weath. Rev.*

Aug. 8.—About 23^h a *very light* shock at Tuckernuck, near Nantucket, which was reported to me by Prof. E. S. Morse, of Salem, Mass.

Aug. 10.—About 14^h 7.3^m a *strong* earthquake occurred in New England and the Middle States, a preliminary notice of which has already appeared in this Journal (xxviii, 242).

In investigating the area affected by this shock, 215 reporting stations were marked upon the map, a reduced copy of which accompanies these notes. The stations were marked in



such a way as to indicate the intensity at each, according to the adopted scale, as inferred from the reported phenomena, and three curves of intensity were drawn. The largest curve includes all stations reporting except Titusville, Pa. The next curve includes all those where the intensity reached III, except Boston, Mass., and Rutland, Vt. The inner curve includes all those reaching IV. The only places where the reported intensity reached V were Jamaica and Amityville in the western part of Long Island. At Jamaica it was stated that "the walls of the Presbyterian Sunday School were cracked in two places, the openings being from one to two inches in width and extending from the roof to the foundation." At Amityville it was reported that "a large mirror which reached from the ceiling to the floor was cracked from the top to the bottom and the walls of the room were cracked in two places. A broom handle can be laid in the cracks in the walls."

The boundary of the largest area passes from the coast near Portsmouth, N. H., to Burlington, Vt., then turning sharply southwest passes about midway between Utica and Schenectady, N. Y., a little east of Binghamton, N. Y., west of Williamsport, Pa., east of Chambersburg, Pa., south of Mechanicstown and Baltimore, Md., and so eastward to the coast again at Atlantic City, N. J., enclosing a land area of about 70,000 square miles. The area of intensity IV is nearly elliptical, its longer axis extending from Hartford, Conn., to West Chester, Pa., and having its centre near New York, being about 200 miles long by 70 miles wide. The long axis of this ellipse is closely parallel to the general direction of the Appalachian chain in this region. At thirty places within this area, fallen bricks, cracked plaster, etc., testified to the power of the earthquake. The shock was reported from Titusville in northwestern Pennsylvania, but was apparently not felt at any other place in that direction beyond Williamsport.

The time observations which appear most reliable are given in the following table:

PLACE.	OBSERVER.	TIME AFTER 14 h.
Shelter Island, (L. I.) N. Y.	Prof. Horsford.	$6^m\ 30^s$.
Seabright, N. J.	(?)	$6^m\ 50^s$.
Asbury Park, N. J.	W. D. Johnson.	7^m.
Point Pleasant, N. J.	Prof. H. A. Newton.	$7^m\ 3^s$ to $7^m\ 7^s \pm 2$ or 3^s.
Morristown, N. J.	C. G. Rockwood.	7^m.
Princeton, N. J.	Prof. C. A. Young.	$7^m\ 30^s \pm 4$ or 5^s.
Germantown, Pa.	W. F. Burr. P. M. Reese.	$7^m\ 20^s$ to $7^m\ 30^s \pm 2^s$.
Brooklyn Heights, N. Y.	S. McElroy.	$8^m\ 30^s$.
Stone Ridge, N. Y.	Prof. I. E. Hasbrouck.	8^m.
New Haven, Conn.	L. Waldo.	$7^m\ 25^s$.
Harvard College.	Prof. Pickering.	$7^m\ 15^s$.

These do not indicate with any certainty a progressive motion from any centre. Assuming the shock, therefore, to have been practically simultaneous at these stations, the mean of these times, or $14^h\ 7^m\ 18^s$, would be the time of the beginning of the earthquake as nearly as it can be ascertained.

The directions reported at fifty-nine stations were plotted and examined. They are as follows:

Northwest and southeast	7
North and south	19
Northeast and southwest	19
East and west	14

The only inference that can be drawn from this statement is that the propagation was in a northeast-southwest direction or the reverse, since the number of northwest-southeast observations is notably less than the others. An examination of the map at once indicates that the cause of this earthquake is to be sought in the vicinity of New York City. The center of the inner curve falls in northeastern New Jersey, where are several dykes of trap rock, prominent among which is the one forming the Palisades, on the west bank of the lower Hudson, and which is continued southward in Bergen Hill to its end in Staten Island. Nor is the presence of these trap dykes the only indication that the vicinity of New York Bay has been a disturbed area in past geological time. The fact that here is the lowest part of the grand Appalachian chain, which reaches much greater elevations in the Catskills and the Green Mountains to the north, and in the Alleghanies to the south; the deflection of the plumb line, which here is toward the ocean instead of toward the mountains; the presence of the bay itself, intensified by the strange depression or valley in the ocean bottom extending seaward from Sandy Hook, as shown in the relief model exhibited by Professor Hilgard at the Philadelphia meeting of the American Association last summer; the comparative frequency of slight earthquakes in this neighborhood; all these point to a condition of the subjacent strata favorable to the occurrence of fractures and faults, which would give rise to the surface phenomena of an earthquake. While the observations in the present case are not sufficiently precise to locate such a fracture exactly, the general inference that this earthquake was due to some rupture of the strata underlying the immediate neighborhood of New York seems sufficiently well substantiated. The observations on direction pointing to a more decided vibration in a northeast-southwest direction, and the longer axis of the smaller intensity curve trending in the same general direction, would indicate that the line of the fracture was northwest and southeast, a direction which is at right angles to the trend of the trap dykes, as also to the strike of the sedimentary strata, and parallel to that of the submarine valley spoken of above.

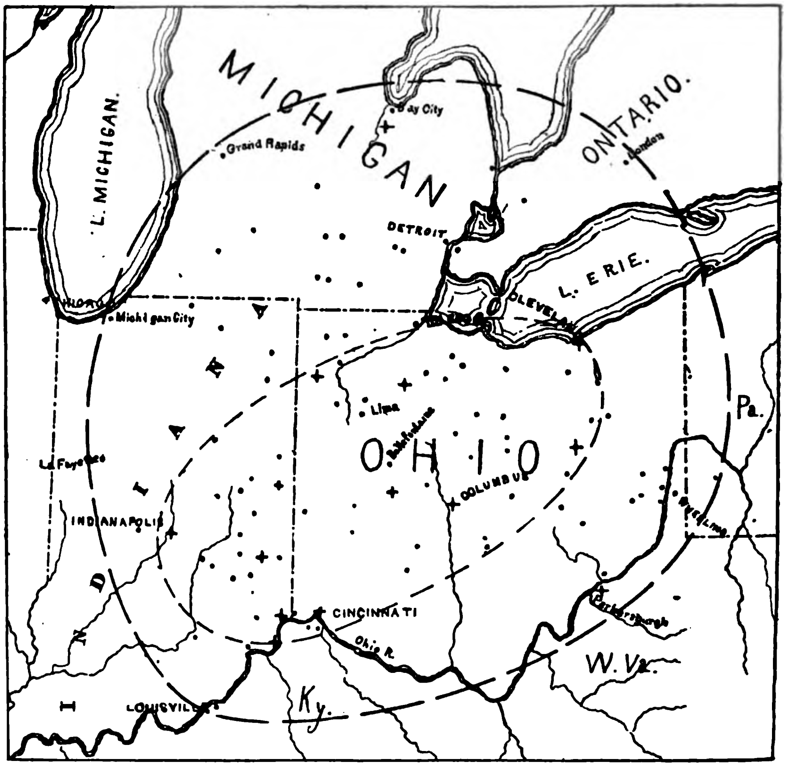
Much time has already been given to the study of the material gathered in regard to this earthquake, the general conclusions of which have been stated, and the hope is still entertained of publishing in due time a more detailed discussion accompanied by a larger map.

There were sundry reports of light succeeding shocks at various hours on the 11th, but none were confirmed by two observers, and all were apparently due to the excited imagination of the public.

Aug. 24.—At 19h 45m a *light* earthquake, rattling windows and accompanied by a low rumbling sound, occurred at Knoxville, Tennessee, and vicinity.

Sept. 10.—An earthquake at Lima, Peru, called in newspaper reports "a strong shock," but no damage reported.—*J. M. B.*

Sept. 19.—At 14h 14·2m central standard time, a *moderate* earthquake was felt in Ohio and Indiana and portions of the



Earthquake, Sept. 19, 1884. • Places reporting. + Greater intensity.

adjacent States. From the accompanying plan formed by marking on the map the positions of one hundred and two places where it was reported to have been felt, its principal area is seen to be approximately defined by the following chain of cities, viz: Louisville, Ky., Parkersburg and Wheeling, West Va., London, Ont., Bay City and Grand Rapids, Mich., Michigan City and Lafayette, Ind. A curved line enclosing these places would include a nearly circular area, with a diameter of about four hundred miles and whose center is a little east of Lima, Ohio; and within this area the reporting stations are seen to be thickly crowded. Reports from Cedar Rapids and Dubuque, Iowa, mention tremors noticed by a few persons there, and corresponding approximately in time with this shock; while a few persons claimed to have felt it faintly in Washington, D. C. Among the latter were workmen on the top of the Washington Monument, at that time about 500 feet high. These last places are far outside of the boundaries given above. Within these lines the shock was evidently not of equal intensity in all places. At Indianapolis and at Vevay, Lawrenceburgh, Connersville and Winchester, all in the southeastern corner of Indiana; at Cincinnati, Urbana, Findlay and Cecil in Western Ohio; at Columbus, Millersburg and Cleveland in Central and Northern Ohio; as also at Parkersburg, West Va. and at East Saginaw, Mich., there were reports of swaying chandeliers, displaced furniture, etc., indicating an intensity reaching III. of our scale. All these places except the last two are in the middle portion of the disturbed area, and would be within an elliptical area with a major axis of about 300 miles directed approximately northeast and southwest, and a minor axis about half as great. This inner curve is not symmetrically placed with respect to the outer one, its center falling about thirty miles south of that of the larger area and near the town of Belle Fontaine, Ohio. Outside of this area, except at the two places mentioned, the reported phenomena nowhere indicate an intensity greater than II of our scale.

The time given above is the mean of twelve reports in which the time given was directly stated to be either "standard" or "local." These are contained in the annexed table, in which, for the last eight places, the dates have been reduced from local time to the standard time of 90° west longitude.

	h. m.		h. m.
Shelbyville, Ind.	2.15 P. M.	Columbus, O.	2.14 P. M.
Metamora, Ind.	2.15	Cleveland. O.	2.14
Archbold, O.	2.13	Newark, O.	2.15
Coshocton, O.	2.15	Detroit, Mich.	2.13
Indianapolis, Ind.	2.14	E. Saginaw, Mich.	2.11
Toledo, O.	2.16		
Cincinnati, O.	2.15	Mean,	2.14.2

At many other places time was reported but without indicating to what standard it was referred.

At many places two or three distinct vibrations were noted, and the duration was variously estimated from three to thirty seconds. Notes of the direction of vibration are given at comparatively few places and present nothing of interest. At Columbus, O., chandeliers were observed to sway from north to south, the motion continuing for at least two minutes.

In seeking for a possible connection between this earthquake and the geology of the region, we at once meet with a very suggestive fact. Crossing the western part of Ohio is an anticlinal, known in the geology of the State as the Cincinnati arch.* Its axis or crest is traced from south to north through Tennessee and Kentucky, crosses the Ohio River a little east of Cincinnati, extends in a direction somewhat east of north, passing near and a little east of Belle Fontaine, and reaches the lake shore between Toledo and Sandusky, some fifteen or twenty miles east of the former. It probably finds its continuation in some islands in Lake Erie. Its bearing is nearly parallel to that of the folds of the Alleghanies. The rocks composing this arch are the Lower Silurian limestones, especially those known as the Cincinnati group, which occupy the crown as far as Dayton, while farther north these are overlaid by the Niagara and later deposits. Professor Newberry† regards this arch as having been upraised between the Lower and Upper Silurian ages, but as having continued to be a line of disturbance through several succeeding geological ages.

I have thought it worth while to state thus some of the facts in regard to this Cincinnati arch, because its axis crosses so exactly over the centers both of the larger area of disturbance and of the smaller area of increased intensity of this earthquake as described above, and the direction of this axis approaches so nearly to that of the long axis of the smaller earthquake area, that a physical connection between the two phenomena is at once suggested. It is natural to infer that this anticlinal arch is still in a state of strain and that the earthquake of September 19th was the direct result of some giving way or snap of the strata forming it, causing a new fault somewhere near Belle Fontaine. It would be interesting in this connection to know if there have been any signs of recent changes of level in that region, or anything else to indicate that the upheaval of this arch may be still in slow progress.

Sept. 21.—Between 22^h and 23^h *light* shocks were felt at New Tacoma, Washington Ter.—*U. S. Weath. Rev.*

Sept. 26.—At 22^h 53^m a *light* shock was felt at Fort Yuma, Arizona, duration ten seconds, vibration south to north. Another very light shock was felt about 3^h of the 27th.—*U. S. Weath. Rev.*

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* Geological Survey of Ohio, vol. i.

† Geol. Surv. of Ohio, vol. i, pp. 103, 106.

Oct. 2.—Two *light* shocks occurred at Rivas, Nicaragua, the first at 14^h 32^m, of two seconds duration, the second after 15^h of about three seconds duration. The latter was also reported as strongly felt at San Juan del Sur at 16^h. The district of Rivas, where these places are situated, occupies the country, about thirty miles wide, between Lake Nicaragua and the Pacific Ocean.

Oct. 10.—In the early morning a *very light* shock at Roxbury and West Newton, Mass., and vicinity.—*J. M. B.*

Oct. 22.—At 15^h 34^m a *light* shock at Los Angeles, Cal.—*U. S. Weath. Rev.*

Oct. 24.—At 0^h 15^m a *very light* shock at Huntingdon, Quebec. —*Canadian Met. Serv.*

Oct. 26.—Shortly after 20^h a *very light* shock was felt at Nashua, N. H. There was a noise as of a heavy explosion followed by a low rumbling sound. The general direction of the tremor was from southwest to northeast, and it continued four or five seconds.—*J. M. B.*

Nov. 4.—The ship "Occidental" reported that at 18^h, when 150 miles off Cape Mendocino, Cal., three shocks of earthquake were felt, followed a few hours later by two heavier ones.—*U. S. Weath. Rev.*

Nov. 5.—A *destructive* earthquake occurred on the isthmus of Panama, in which Aquadas and Pacoria suffered severely, churches, public edifices and private houses being overthrown, with damages estimated from $250,000 to $400,000.—*Newark (N. J.) Daily Advertiser.*

Nov. 6.—Despatches from Buenaventura, States of Colombia, report that a *severe* earthquake was felt on the night of the 6th at Cali and other towns in the Southern States. The church of San Pedro at Cali was wrecked and other buildings suffered severely.

It is possible that the last two items may refer to the same occurrence. The hour was not stated in either case.

Nov. 9.—About 2^h a *strong* earthquake was felt at Fort Bridger, Wyoming, at Salt Lake City, Utah, and at Paris, Idaho. At Fort Bridger "telegraph wires swung perceptibly," the duration was five to ten seconds and the direction west to east. At Paris six shocks were reported between 2^h and 4^h. Here also "considerable damage to houses is reported and people were affected by sea-sickness." The notes in regard to Salt Lake City and Paris are from the Kansas City Review of Science, where the date is given *Nov.* 10. But both accounts seem evidently to refer to the same occurrence which is known to have occurred on Nov. 9 at Fort Bridger.

Nov. 12.—About 19^h 50^m a *light* earthquake occurred in Southern New Hampshire, being reported from Concord, Hopkinton, Bradford and Warner in Merrimack County, and Hillsborough and Antrim in Hillsborough County.

Nov. 12.—The self-registering tide guage at Saucelito, Cal., recorded a series of waves probably due to a submarine earthquake. They are thus described in the San Francisco Evening Bulletin of Dec. 13. "They commenced at eight o'clock in the morning and ended at eleven. There are nine well-marked crests in two and a half hours or only seventeen minutes apart. They are only two or three inches in height but maintain the characteristic earthquake features, in plain contrast with the breaking bar markings, which are very sharp and frequent. It would appear from the height and length of the waves that this submarine earthquake took place near our coast and was not violent."

Nov. 13.—The so-called earthquake reported on this date in Essex County, Ontario, was caused by an explosion of powder at Toledo, Ohio.

Nov. 21.—In the evening several places on both sides of the St. Lawrence River; between St. Flavie, Kamouraska Co., and Gaspé, a distance of about 250 miles, were visited by a *light* earthquake. The vibration lasted 45 or 50 seconds, but did no damage, although creating alarm.

Nov. 22.—At 7^h 13^m a *destructive* earthquake occurred at Lima, Peru, and vicinity. The motion was from southwest to northeast. At Callao portions of the cliff were shaken down upon the beach. The walls of many houses were cracked and some were shaken down. At Chorillos a series of cracks were opened nine yards from the edge of the cliff.

Nov. 23.—At 0^h 30^m a *strong* earthquake occurred in New Hampshire, Eastern Massachusetts and Connecticut. At Concord, N. H., a light shock was followed by a heavier one sixteen minutes later, direction west to east, accompanied by a rumbling noise loud enough to awaken people. At Henniker, N. H., the foundation of a boiler was displaced. It was "extensively felt in that part of the State." It was reported as lightly but distinctly felt at Plymouth, Grafton Co., N. H., at New Ipswich and Cliftondale, Essex Co., at Cambridge and at Holden, Worcester Co., Mass., and at Hartford and Mansfield, Conn. At the last-named place seven or eight shocks were noted in rapid succession, increasing in intensity from first to last. The time of the occurrence, a half hour after midnight, will probably account for its not having been more generally noticed at intervening places.

Nov. 29.—About 23^h a *light* shock occurred in Western Tennessee, reported from Memphis, Covington and Dyersburg. The direction was generally stated as west to east or southwest to northeast, duration variously given from five seconds to a minute. It was accompanied by a rumbling noise.

Dec. 4.—At 0^h 18^m a *very light* shock at Northampton, Mass.—*Bull. N. Eng. Met. Soc.*

Dec. 17.—At about 2^h a *light* shock was felt at Laconia and Center Harbor, Belknap Co., N. H.

The above list contains fifty-four items not counting the one of Nov. 13, of which seven are in small type. They may be geographically classified thus:

Canadian Provinces	5
New England	9
Atlantic States	5
Mississippi Valley	7
Pacific Coast	21
West Indies	2
Central America and Colombia	3
Peru	2
Uruguay	1
	55
Deduct for Aug. 10, counted twice	1
	54

By seasons they are classified thus:

Winter, 12 (Dec., 2; Jan., 8; Feb. 2); Spring, 15 (Mar., 8; Apr., 7; May, 0); Summer, 8 (June, 4; July, 0; Aug., 4); Autumn, 19 (Sept., 4; Oct., 5; Nov., 10); Spring and Summer together, 23; Autumn and Winter together, 31.

The following localities were shaken on two or more days, viz:

Los Angeles, Cal., Jan. 4, Jan. 16, Oct. 22; San Francisco, Jan. 25, Mar. 15, 25, July 15, Nov. 12; Oakland, Cal., Mar. 25, April 17, 20; Eureka, Cal., Jan. 27, April 6, 8, 11; Concord, N. H., Aug. 10, Nov. 12, 23.

The only shocks causing much damage were Nov. 5, Panama; Nov. 6, Colombia; Nov. 22, Lima, and Aug. 10, Middle States.

Princeton, March 28, 1885.

ART. LV.—*Taconic Rocks and Stratigraphy;* by JAMES D. DANA.

[Continued from page 222.]

V. *Metamorphism and Mineral Constitution in the Taconic Region, gradational from West to East and from North to South.*

THE succession in the different lithological areas exhibited on the map of the southern portion of the Taconic region (published with the preceding part of this paper) is as follows, beginning on the west:

(1.) Winchell's Ridge of schist and other small ridges in Copake north of it.

(2.) The western belt of limestone, passing through Copake and Millerton.

(3.) The limestone area in Salisbury, with its isolated schist ridges, extending eastward to the Housatonic River and continued across the river far into Canaan (the river being the political boundary between the two towns).

(4.) Schist to the eastward of the outcropping limestone in

Canaan mountain, and probably part of that of other eastern ridges.

The underlying position of the limestone was proved by the fact of universal *eastward dips* in the schist and limestone on the *west* side of the various schist ridges and the occurrence of *westward dips* along the *east* side of Mt. Washington, the two concurrent facts proving that the mountain is synclinal in structure; and also by stratigraphical sections from other ridges. In view of this underlying position over the whole breadth of the region from Canaan mountain to Winchell mountain, and the actual continuity of the limestone over Salisbury and Canaan, and over the adjoining towns north in Massachusetts, it was concluded that the limestone, with some intercalations of schist, was one continuous stratum or formation. By similar evidence it was shown that the overlying schist belonged to one continuous stratum.

I have given no descriptions of the iron-ore deposits along the marginal portions of the limestone areas because they are of secondary origin. But it is to be noted that if the view of their origin which I believe to be sustained by the facts* is correct, they prove that during the transition from the making of the limestone to that of earthy sedimentary deposition there were in some parts conditions favorable to ferriferous depositions over the calcareous sediment; in other words, there were great sea-border marshes or basins to receive contributions from iron-bearing waters. These depositions, however, were local, as such always are, and are very far from indicating the presence of a universal stratum of more or less ferriferous limestone (with some included iron carbonate) adjoining the stratum or strata of schist. Yet it is true that the adjoining portion of the limestone, sometimes for scores of feet in thickness, is generally very impure from mixture with the materials of the schist.

The several ore-pits are designated on the map by letters; I give here their names, adding an asterisk to those that were worked in 1884.

In Salisbury: *b*, Ore-Hill*; *c*, Chatfield*; *d*, Porter; *e*, Forbes*; *f*, Clarke's; *g*, a partial opening; *h*, Scoville's, the ore mostly manganese oxide, and accompanied sparingly by the mineral Scovillite; *i*, Camp's. In Sheffield: *j*, Little's. In New York: *k*, Copake*, or Miles's; *l*, Weed's*; *m*, Couch; *n*, Mt. Riga*, or Cheaver; *o* (in Ancram), Reynolds; *a*, Millerton or Maltby.*

We have now to consider *the variations in degree of metamorphism*, and *in mineral constitution* in these two strata on going over the region from west to east and from north to south.

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* This Journal, xxviii, 398, Nov. 1884.

1. THE SCHIST WITH THE QUARTZYTE.

The schist of the region varies from very fine-grained thin-fissile glossy hydromica (or sericite) schist to coarsish mica schist containing garnets and staurolites; and toward the east, to arenaceous or quartzytic mica schist without staurolite, and mostly without garnets. Each of the rocks contains disseminated magnetite, and often pyrite, and sometimes these minerals are in distinct crystals. Minute brown or brownish tourmalines also are found sparingly in all the kinds.

The term *quartzose* or *quartzytic* is used beyond synonymously with arenaceous, it referring to the occurrence of quartz grains in the schist and not to vein quartz. In the hydromica and mica schist the grains lie in small, thin or thick, interrupted layers between the leaves of the schist, as if deposited like the interrupted laminations of sand in some river-valley clays; they vary in length from an inch to many feet, and in thickness from $\frac{1}{100}$th of an inch and less, to $\frac{1}{2}$ inch or more; they are smallest in the finest of the slate.

The facts mentioned below are from both macroscopic and microscopic examinations.

A. *Section through the Southern part of Mt. Washington from Winchell Mountain to Canaan Mountain.*

1. *Mt. Winchell.*—At the summit of Mt. Winchell the rock is thin-fissile hydromica (or sericite) schist. It consists chiefly of muscovite mica in minute scales about $\frac{1}{250}$ to $\frac{1}{300}$ inch across, and has the fusibility of the mica. Biotite mica is rare. Quartz grains are sparingly present in delicate interlaminations, as seen in a transverse section. Minute tourmalines rather rare. Chlorite not observed either macroscopically or in the thin slices. At the eastern foot of Mt. Winchell the rock is the same, but slightly coarser and often a little crumpled (from pressure). Muscovite scales are mostly $\frac{1}{100}$ to $\frac{1}{200}$ inch across; some biotite scales occur $\frac{1}{50}$ to $\frac{1}{100}$ inch across and generally grouped.

2. *West side of Mt. Washington.*—North of Millerton—about a mile east of the base of Winchell mountain—the rock is a very fine-grained mica schist, consisting chiefly of muscovite, with little chlorite; muscovite scales mostly $\frac{1}{50}$ to $\frac{1}{200}$ inch; the biotite scales larger. Quartz grains in thin interlamination often making up a fourth or more of the thickness. Garnets are few and small, or absent; orthoclase feldspar is found in occasional grains; staurolites are absent.

3. *East side of Mt. Washington, in Salisbury.*—The schist is a coarsish muscovite mica schist with some biotite and usually no chlorite; muscovite scales about $\frac{1}{100}$ to $\frac{1}{30}$ inch, and biotite

$\frac{1}{16}$ to $\frac{1}{4}$ inch. Interlaminations of quartz generally make more than a fourth of the thickness. Garnets are abundant, $\frac{1}{12}$ to $\frac{1}{8}$ inch. Staurolite crystals abundant in some portions, $\frac{1}{3}$ to $\frac{1}{4}$ inch long and less. Orthoclase sparingly present. Minute tourmalines of occasional occurrence both in the quartz seams and the micaceous portion.

4. *Three miles east of Mt. Washington on the eastern border of Salisbury.*—The schist is similar to the preceding but somewhat coarser; muscovite scales $\frac{1}{16}$ inch and less; biotite more common than in the Mt. Washington schist. Interlaminations of quartz often make half the thickness of the schist. Garnets abundant and staurolites common in many layers, $\frac{1}{3}$ to $\frac{2}{3}$ inch long, mostly $\frac{1}{2}$ inch.

5. *East of the Housatonic* (*and of Salisbury*) *in Canaan.*—The schist is partly normal mica schist, but generally a very arenaceous or quartzytic mica schist, the quartz $\frac{3}{4}$ths to $\frac{9}{10}$ths and more of the material; the mica mostly biotite, but in some small portions muscovite predominates. Garnets are few and small, or absent.

Quartzyte in strata occurs with the schist, both the fragile bedded kind and the hard massive. It consists of quartz grains with some orthoclase and microcline, often some mica, not unfrequently minute tourmalines.

The schist and quartzyte contain *no* staurolites. This fact comports with the constitution of this mineral, which ordinarily contains less than 31 per cent of silica and over 48 of alumina.

Going farther east in Canaan mountain the schist changes to a normal mica schist.

B. *Section through the northern part of Mt. Washington from Copake through Sheffield commencing at the west.*

1. *In Copake, New York.*—The schist of the small ridges north of Winchell Mountain is a very thin fissile hydromica (or sericite) schist, like the Winchell slate, but of finer grain; looks like a smooth, glossy roofing slate. Contains no garnets.

2. *West side of Mount Washington, near Copake Furnace.*—The rock is a greenish or chloritic hydromica schist, with also mica schist. It is sparingly garnetiferous; without staurolites.

3. *East side of Mount Washington in Sheffield.*—The schist is like that on the west side, but it is coarser, and a larger part is true mica schist. It contains garnets, but no staurolites were found. Minute tourmalines occur in it.

4. *Three miles east of Mt. Washington near the village of Sheffield, west of the Housatonic.*—The schist is a coarsish mica schist, garnetiferous, and containing small staurolites. It resembles the schist of the southern part of the east side of Mt. Washington in its degree of fineness and in its staurolites, and

is less coarse than that directly south in Salisbury, near Limerock Station.

5. *East of Sheffield village, and of the Housatonic River.*—The schist is the same *arenaceous* mica schist that occurs to the south in Canaan, and, as there, it alternates with, and often graduates into a great formation of quartzyte. North of Sheffield village, west of the Housatonic, the same quartzyte, partly micaceous, constitutes the south end of a ridge that extends north into Great Barrington.

C. *Conclusion.*

The facts here reviewed relate, it should be remembered, to a single stratum, that overlying the limestone. Since the change from west to east is so strongly marked even in Mt. Washington, only five miles broad, and in one and the same lower portion of the schist, or that directly over the limestone, the facts have special interest.

The change is of two kinds—(1) *a change in degree of metamorphism ;* (2) *a change in mineral constitution.*

(1) *An increase eastward in intensity of metamorphic action.* This is manifested—

(*a*) In the gradual increase in size of the scales of mica ; (*b*) in the change from hydrous mica to ordinary mica in the Mt. Washington schists, and in the occurrence of the latter alone east of Mt. Washington ; (*c*) in the absence of chlorite (another hydrous mineral) from the southern half of *eastern* Mt. Washington and its absence from the schist of ridges farther east; (*d*) in the increasing size of the garnets and staurolites on going eastward over Salisbury.

(2) The *change in mineral constitution*, beyond what has been stated in the preceding paragraph, is as follows:

a. Biotite mica, which is very sparingly present in the Winchell slates, increases in amount in eastern Salisbury, and is much the most common kind in the arenaceous schists to the eastward.

b. Granular quartz, which is very sparingly present in the Winchell slates, gradually increases in amount eastward, is rather abundant in the southern part of eastern Mt. Washington, and still more so in eastern Salisbury ; and east of the Housatonic for a breadth of two miles or more it is the preponderating constituent in the mica schist and composes quartzyte strata.

c. Tourmaline in minute crystals is sparingly present in the western schists and much less sparingly in the quartzyte and quartzytic mica schist to the eastward.

d. Garnets, which are not present in the Winchell slates, occur very small in western Mt. Washington, and increase in abundance and size to the Housatonic; but are few and small in the arenaceous schist east of the Housatonic.

e. Staurolites occur of very small size in the southern half of eastern Mt. Washington, and are, on an average, twice longer in eastern Salisbury. In the northern half of Mt. Washington, staurolites have not been found, but they occur in the coarsish mica schist three miles farther east. (This interval of three miles is occupied by limestone so that no nearer observation is possible.)

f. Orthoclase is very sparingly present in the hydromica (or sericite) schist to the west; but is less rare in the mica schist west of the Housatonic, and still less so in part of the quartzytic mica schist east of the Housatonic; in some of it, the feldspar is partly the species microcline.

Looking at the *constitution of the minerals*, we learn that to the west of the area of Mt. Washington the sediments of which the rock is made were very fine earthy, containing little quartz; that the amount of quartz sand in the sediments increased to the eastward; and that toward the eastern limit of the region, sand was the chief material. The occurrence of arenaceous mica schist overlying, underlying and interlaminating quartzyte beds indicates a small change at intervals in the kinds of depositions such as may have come from changing depths or currents.

All the facts derived from the constitution of the rocks point to a single system of hydrographic conditions and sedimentation; and none suggest the subsequent occurrence of great displacements by long overthrusts any more than those that have been gathered from the stratigraphy. The lithological observations accord with the stratigraphical.

The stratification described is true stratification and not that of a subsequently induced cleavage-structure; for the beds of mica schist, quartzyte and limestone are parallel in interlaminations and interstratifications. Cleavage structure is a common source of lamination in the hydromica (sericite) slates west of Mt. Washington; and hence the true planes of bedding can there be learned only from the contact portions of the limestone and slates; but it is much less common farther east; and the danger of error has been avoided in the observations I have made by taking them at or near the contacts of the different strata or rocks.

The variations geographically from arenaceous to fine earthy beds are just such as are common among the non-crystalline strata farther west, and just such as belong to modern depositions over a region of emerging coasts or flats with an adjoining shelving bottom for a score of miles or so outside. In this part of the Taconic region, the shelving bottom was to the *west* of the emerging flats—how far west it extended it is not yet safe to say;—while to the east and south there were, as I have already explained, *isolated* areas of emerged or submerged Archæan rocks, and, adjoining them, in some places, unconformably overlying sandstone (now quartzyte) which is probably of Primordial age.

The gradation in metamorphism does not vary with the amount of flexure in the beds, in this part of the Taconic region, but has depended on some more comprehensive action of this or some other cause.

2. LIMESTONES.

The above conclusion as to increasing grade in metamorphism from west to east is sustained by facts from the limestone of the region that were long since made known by Dewey and Emmons and have been confirmed by all observers. While all is crystalline, the rock west of Mt. Washington is fine-grained and often gray in color; that in Salisbury and Sheffield is a little coarser, ranging from gray to white, the latter much predominating; and in Canaan and to the north, east of the Housatonic, it is mostly a coarse marble and much of it abounds in tremolite, and often also in large crystallizations of white pyroxene. The latter mineral sometimes appears as a rock, called canaanite, in the upper part of the limestone. The tremolite and white pyroxene of the limestone, which are among the results of the metamorphic action that crystallized the limestone, occur to the eastward where the overlying beds are especially arenaceous; and their silica, as I have long since explained, may have been derived from the silica originally in the limestone as an impurity. The limestone is *carbonate* of calcium and magnesium; and tremolite and pyroxene are *silicates* (or rather bisilicates) of calcium and magnesium.*

The gradation in metamorphism from north to south, which the preceding remarks have partly illustrated, I leave without review at this time, as the subject will be better explained after the facts relating to the rest of Berkshire have been presented.

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* In a paper in this Journal for 1844 (xlvii, 135) and again in 1846 (II, ii, 88) I point out the fact that the silicates, as well as phosphates, in crystallized limestones may have derived their ingredients from the impurities of the original limestone, though not excluding the possibility of an accession of silica and alkalies sometimes from outside siliceous waters. In my Manual of Geology, edition of 1863 (the first) and later, I make the impurities of a limestone the source through metamorphism, of "its crystalline minerals such as *garnet*, *idocrase*, *pyroxene*, *scapolite*, *mica*, *sphene*, *chondrodite*, *apatite*, etc." My statements in an article on the limestone of Westchester County in this Journal for 1880 (xx, 28) appear to have led astray Messrs. King and Rowney in "An Old Chapter of the Geological Record," pp. 42, 59. I speak of the tremolite and white pyroxene as a result of the action of hot silicated solutions on a magnesian limestone; but my opinion was then the same as stated in my Geology—that the hot silicate solutions were made within the limestone by the action of heat on the moisture and silica present as impurity.

ART. LVI.—*Notes on the possible age of some of the Mesozoic rocks of the Queen Charlotte Islands and British Columbia;* by J. F. WHITEAVES.

As far back as the year 1869, Mr. W. Gabb expressed the opinion that the Californian rocks, to which he gave the provisional name of the "Shasta Group," were probably the equivalents of the Gault and Neocomian of Europe, and this view was endorsed by Prof. J. D. Whitney. On behalf of the Canadian Survey Mr. J. Richardson visited the Queen Charlotte Islands in 1872, and made a small but interesting collection of fossils from the coal-bearing deposits of Skidegate Inlet. Among the species recognized at this locality were *Ammonites Breweri*, *A. Stoliczkanus* and *Aucella Piochii* of Gabb, of the Shasta group of California, also *Ammonites Timotheanus* Mayor, and *Inoceramus concentricus*, of the European Gault, but associated with these were several new Ammonites which appeared to have rather a Jurassic facies. The conclusion reached on this rather meagre and unsatisfactory evidence was that the rocks bordering Skidegate Inlet could scarcely be much older than the Upper Jurassic or much newer than the Middle Cretaceous.

Four years later Dr. G. M. Dawson obtained a small series of fossils from the bedded volcanic rocks at the Iltasyouco River and Sigutlat Lake, in the Coast Range of British Columbia. Having then no reason to doubt the correctness of Mr. Meek's conclusion that certain rocks in the Black Hills of Dakota were of Jurassic age, the writer of the present article at once assumed that the Iltasyouco and Sigutlat fossiliferous strata were also Jurassic, on account of their holding such fossils as *Gryphæa Nebrascensis*, *Volsella formosa*, *Astarte Packardi*, *Pleuromya subcompressa*, and the like.

The exact age of the "Aucella schists" of Russia, Siberia, etc., has been the subject of much discussion, and European geologists are still at issue on this point. D'Orbigny, in 1846, places them in the "Oxfordien" division of the Jurassic. Trautschold (1864 and 1866) claimed that they are about the age of the Kimmeridge Clay, but later (in 1875) placed them at the extreme summit of the Jurassic system, in the Tithonic Group of Oppel, and this latter view is also maintained by Rudolph Ludwig. Ever since 1867, however, Eichwald has strenuously argued that they are Necomian, and in the only geological section of these rocks which the present writer has seen, the *Aucella* schists are represented as immediately and conformably overlying the Kimmeridge Clay, as the Gault does at Culham in Berkshire (England), a circumstance which many of those who attended the late Prof. Phillips's geology class at

Oxford will remember. Since 1875, deposits holding large numbers of *Aucella Piochii* Gabb (which can scarcely be distinguished from the *A. Mosquensis* of Europe), with a few other fossils, have been discovered by members of the Canadian Survey at several localities on the west coast of British Columbia, on Vancouver Island at Forward Inlet, and in the valley of the Peace River. In a paper "On the Lower Cretaceous rocks of British Columbia" published in the first volume of the Transactions of the Royal Society of Canada, the writer expressed the opinion that those deposits in California and British Columbia, which are characterized by the presence of *Belemnites impressus*, *Ancyloceras percostatus* and more especially by an abundance of *Aucellæ*, represent the lower half of the Shasta Group and are the equivalents of the Upper Neocomian of Europe.

In 1878 Dr. G. M. Dawson, accompanied by his brother, visited the Queen Charlotte Islands and devoted the whole season to an examination of their geological features. From his detailed report upon these islands, which was published in 1879, it appears that the central portion, which includes both shores of Skidegate and Cumshewa Inlets, is occupied by strata which there is now every reason to believe are of Cretaceous age. In descending order the section of these Cretaceous rocks given by Dr. Dawson is as follows. No. 1. The Upper Shales; these have so far yielded only several specimens of *Inoceramus problematicus*, and are therefore supposed to represent the base of the Upper Cretaceous. No. 2. Coarse Conglomerates; these have as yet afforded no fossils that can be identified, but from their position may be assumed to be the equivalents of the Dakota Group. No. 3. The Lower Shales; with coal and iron ore and an abundance of fossils, of which upwards of seventy species have now been described. No. 4. Agglomerates, with a few very indistinct fossils, and No. 5. The Lower Sandstones; these two, from their faunal relations, are believed to be only minor subdivisions of No. 3.

The Lower Shales, or sub-division 3 of Dr. Dawson's report, contain a very rich and varied fauna quite unlike that of any other Cretaceous deposits heretofore recognized in North America. These shales, which the writer has elsewhere ventured to designate "The Queen Charlotte Island Series," are believed to represent the upper part of the Shasta Group of California and the Gault of Europe. Among the fossils which they hold in common with the Shasta Group are *Haploceras Breweri*, *Lytoceras Batesi*, *Hoplites* (?) *Stoliczkanus*, and *Ancyloceras Rémondi*. They have yielded such charcteristic Gault species as *Schloenbachia inflata*, *Haploceras Beudanti*, *planulatum* and *Timotheanum*, *Lytoceras Sacya* and *Thetis major*, var., often in large numbers, also an abundance of *Inoceramus concentricus* and *Actino-*

ceramus sulcatus. As might have been expected, out of the seventy or more species which they contain, a few range upward into the Chico Group of the Upper Cretaceous, and at least three into the lower division of the Shasta Group, which for that reason is supposed to represent the Upper rather than the Lower Neocomian. But, associated with what appear to be purely Cretaceous types, the Lower shales of Skidegate and Cumshewa Inlets hold also at least four or five new species of Ammonites which have recently been described from unusually perfect and well preserved specimens, and which seem to belong to genera, to sections of genera, or to species, which in Europe would be regarded as exclusively Jurassic in their character.

Moreover it is now quite clear that the fauna of the Iltasyouco River and Sigutlat Lake rocks, which the writer at first regarded as of Jurassic age, is essentially the same as that of the Lower shales of Skidegate and Cumshewa inlets. In the coal-bearing strata of the Queen Charlotte Islands and in the volcanic rocks of the Coast Range of British Columbia, associated with characteristic Cretaceous invertebrates, about a dozen species of fossil mollusca have been collected, which the present writer, after long and careful study, has been unable to separate specifically from fossils which Meek and Dr. White have described as Jurassic. A similar apparent mixture of "Jurassic" and Cretaceous fossils occurs in rocks immediately overlying the Alpine Trias, on the Peace River.

Judging exclusively by the invertebrate fossils which they contain and by the stratigraphical position which they are said to occupy, the writer, in a recently published report,* has given at some length his reasons for thinking that the Jurassic age of certain strata in Dakota, Montana, etc., is not yet conclusively proved. The evidence afforded by the vertebrates of these rocks is quite another question and one which has to be considered on its own merits. This aspect of the case has not been discussed at all in the report referred to, for the simple reason that there is not a vestige of a vertebrate, not even a fish scale, in the collection reported on.

In a paper "On the Jurassic Strata of North America," published in the March number of this Journal, Dr. C. A. White objects to the present writer's suggestion that some of the supposed Jurassic rocks of the Western States may possibly be of Middle Cretaceous age, and to the identification of a few fossil mollusca upon which this suggestion was based.

Dr. White's long experience as a paleontologist and his extensive knowledge of the fossil invertebrates of the United

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* Mesozoic Fossils, vol. i, Part 3; On the Fossils of the Coal-Bearing Deposits of the Queen Charlotte Islands, collected by Dr. G. M. Dawson in 1878. Montreal, 1884.

States and Territories entitle any views he may express on such subjects to the fullest consideration, and his intimate acquaintance with and ready access to Meek's types from the Black Hills are unquestionably a great advantage. Unfortunately, however, Dr. White could only spare part of a single day for the examination of the large series of Mesozoic and Laramie fossils in the Museum of the Canadian Survey at Ottawa, and only a few minutes each to a study of those species whose identification he objects to.

To the general statements made at the commencement of Dr. White's paper no special exception need be taken here except perhaps on the ground of their want of novelty. They are, in effect, a résumé of that part of Clarence King's volume on the "Systematic Geology" of the United States Exploration of the 40th Parallel which treats of the Jurassic rocks. In that volume, however, Prof. King distinctly states that the Dakota and "Jurassic" rocks are conformable in the Wahsatch Region, also that according to Meek, Hall and Whitfield, the "Jurassic" fossils from the east base of Augusta Mountain have "a Cretaceous and even an Eocene look."

To Dr. White's presentation of the statements and arguments on the other side of the question the writer begs respectfully to demur.

Dr. White says that in the memoir which he criticizes the author thereof "describes and figures *some* fossils" . . . . which are "*reported* to come from certain strata," etc., thereby leading any reader who is ignorant of the facts to suppose that the number of specimens is small and that it is not altogether certain where they came from. Not counting the fossils previously brought back by Mr. Richardson, Dr. G. M. Dawson's collection alone consists of upwards of one thousand specimens, every one of which is labeled not only with its exact locality but also with the precise subdivision of the series in which it was found.

Out of the twelve forms collected by Dr. Dawson which the writer has referred to North American "Jurassic" species, Dr. White objects to the identification of nine, and with regard to these the following remarks are submitted:

1. *Belemnites densus* Meek and Hayden. The specimens described by Mr. Meek under this name are represented as being short and thick or long and slender, as having an apical groove, a median groove or no groove at all. Dr. White says that "Mr. Whiteaves' collection contains only one specimen which he refers to this species," whereas there are two of the short and thick form, seven of the long and slender variety (to which in accordance with a suggestion of Mr. Meek's, the writer gave a local and provisional name) and several large phragmocones.

Moreover this series was directly compared with authentic specimens of *B. densus* from Dakota, received from Mr. Meek, and it was found necessary to mark all the fossils from the two localities as it would otherwise have been impossible to separate them.

2. *Lyosoma Powelli* White. The fact that the writer gave a different generic and specific name to *Vanikoro pulchella* is a sufficient indication that the analogy between it and *L. Powelli* was supposed to be more remote than that which is supposed to obtain in any of the other instances cited.

3. *Pleuromya subcompressa* Meek. The type of this species was figured by Meek in 1873, and since then Dr. White has illustrated three well marked varieties of it. Specimens which agree perfectly with the descriptions and figures of three out of these four forms have been collected at the Queen Charlotte Islands, and two at the Iltasyouco River and Sigutlat Lake.

4. *Astarte Packardi* White. Dr. White admits that, as far as external shape and surface markings are concerned, it is scarcely practicable to separate the British Columbia and Queen Charlotte Island specimens from this species, but says that the hinge and interior markings of the type of *A. Packardi* are unknown. In this genus, as every experienced malacologist is aware, the interior of the valves affords a certain indication of its generic relations but is of very little assistance in the determination of species.

5. *Grammatodon inornatus* Meek and Hayden. Dr. White says that "Mr. Whiteaves' specimens do not show the hinge." This is quite correct as regards the fossils from the Queen Charlotte Islands, but one of the specimens from the Iltasyouco River shows the impression of two short posterior lateral teeth parallel to the hinge line, just as in Meek's figure of *G. inornatus* on plate 3, fig. 9b, of the "Palæontology of the Upper Missouri."

6. *Modiola* (*Volsella*) *subimbricata* Meek. The specimens from the Queen Charlotte Islands referred to this species, though somewhat distorted, are nearly perfect single valves. Dr. White does not comment at all on the real or supposed identification of a Sigutlat Lake specimen with the *Modiola* (or *Volsella*) *formosa* of Meek and Hayden, one of the strongest points in the writer's view of the case. At the Iltasyouco River, too, specimens have been found which are very difficult to distinguish from *Modiola platynota* White.

7. *Pteria* (*Oxytoma*) *mucronata* Meek and Hayden. Of this the writer is said to have only one imperfect valve and Dr. White adds "that the most that can be said of it is that it apparently indicates a form which is much like the *P.* (*O.*) *mucronata* of Meek and Hayden." In answer to this statement

it may be observed that while only one imperfect valve was collected in Alliford Bay, yet several perfect specimens of both valves were obtained at Maud Island. In the writer's judgment the least that can be said of the whole of the specimens collected by Dr. Dawson is that they agree perfectly with Meek's description and figure of *Pteria* or *Oxytoma mucronata.*

8. *Camptonectes extenuatus* Meek and Hayden. The lower valve of a small Pecten from Maud Island which was somewhat doubtfully identified with this species is quite perfect in marginal outline, has most of the test preserved, with its characteristic sculpture, and shows the shape of both ears. An upper valve, from the Iltasyouco River, corresponds remarkably well with Meek's figure of the type of *C. extenuatus.*

9. *Gryphaea Nebrascensis* Meek and Hayden. Dr. White says that the specimens, regarded by the writer as probably identical with this species, are more like *Gryphaea navia* Conrad. The irregular, radiating striæ on the umbonal region which are characteristic of *G. Nebrascensis*, and which are well seen on specimens from the Queen Charlotte Islands and from the Iltasyouco River, are altogether absent in *G. navia*, which latter shell has also a narrowly subtrigonal outline with angulated beaks and a sharp umbonal ridge, a combination of characters which is not seen in *G. Nebrascensis*, nor on any of the specimens collected by Dr. G. M. Dawson.

ART. LVII.—*Crystallized Tiemannite and Metacinnabarite;* by SAMUEL L. PENFIELD.

1. TIEMANNITE.

IN October last, Professor J. E. Clayton, president of the Salt Lake Mining Institute, sent to Prof. G. J. Brush a few specimens containing crystals of a selenide of mercury which were suitable both for analysis and measurement. The specimens were from Marysvale, Southern Utah, the same locality which afforded the sulpho-selenide of mercury, onofrite,* described by Professor Brush. A description of the occurrence of the mineral, as stated by Prof. Clayton, is given at the end of this article, and I take great pleasure in here expressing to him my thanks for calling our attention to these most interesting crystals.

The crystals are black, with high metallic lustre and black streak; hardness about 3; specific gravity taken twice on a chemical balance 8·188–8·187; fracture conchoidal; very brittle and with no apparent cleavage.

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* This Journal, III, xxi, 312.

A analysis was made by decomposing the mineral in a current of chlorine gas, precipitating the mercury as sub-chloride by means of phosphorous acid and the selenium with sulphurous anhydride. The results are given below with the determinations of small amounts of sulphur, cadmium and insoluble residue.

		Ratio.		
Se	29·19	·369	·381	1·00
S	·37	·012		
Hg	69·84	·349	·352	0·92
Cd	·34	·003		
Insol.	·06			
	99·80			

The ratio of the selenium plus sulphur to the metals is 1 : 0·93 or nearly 1 : 1, that required by a normal selenide, and as the impurities are present only in very small quantities the mineral may be regarded as a simple selenide of mercury. The analysis agrees more closely with the theoretical requirements than any previously published, which may be in consequence of the greater purity of the crystallized material.

The crystals measure up to 3^{mm} in diameter. They are isometric, tetrahedral, and the habit of the few at my disposal is quite various. The plus and minus tetrahedrons are usually about equally developed and vary in luster; the cubic faces are also prominent and are at times striated diagonally parallel to their intersection with the dullest tetrahedron and most developed $\frac{1}{2}(m\text{-}m)$ forms. Twins with *o* as the twinning-plane are common. Taking the forms of the most developed $\frac{1}{2}(m\text{-}m)$ as positive, the observed forms are as follows: *o* (111, +1), usually dull, *o*′($\bar{1}11$, −1) lustrous, *a*(001, *i*-*i*), *w*(511, +5-5) and *φ*(733, $+\frac{7}{3}\text{-}\frac{7}{3}$). The above forms were all observed on one twin crystal, fig. 1, the latter *φ*, as a very small face but giving distinct reflections. The faces in both halves of the twin crystal figured are lettered alike except that those in twin position are underscored. Twins on the specimens in my possession are more common than single crystals, some of them showing simply both tetrahedrons and cube.

Fig. 1.

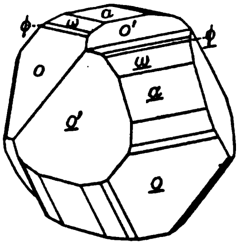
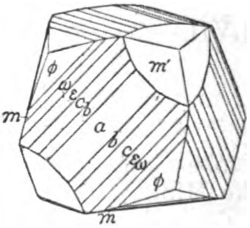


Fig. 2.



The measured angles are the following, the mean of closely agreeing results being given:

		Observed.	Calculated.
o ∧ *o′*, 111 ∧ $\bar{1}11$	=	70° 31′	70°32′
a ∧ *o′*, 001 ∧ $\bar{1}11$		54° 45′	54°44′
a ∧ *ω*, 001 ∧ 115		15° 45′ 15° 50′	15°48′
a ∧ *ϕ*, 001 ∧ 337		31° 10′	31°13′

A number of crystals have the habit shown in fig. 2; only one was lustrous enough to admit of measurement. The zone *a*, *b*, *c*, etc., was very much striated and distorted through oscillatory combination, but by turning the crystal so as to catch the light reflected from it, it could be readily seen to consist of several distinct forms. On the reflecting goniometer the signal was reflected from the faces in almost an unbroken band; a few of the most prominent reflections, however, were recorded and are given below. The reflection from the faces of a lamplight placed at a distance across a large room was resorted to, all the faces of like inclination reflecting together and yielding a sort of "schimmer Messung;" the results of which although not very exact being sufficiently so to fix the symbols of the different forms. The measurements taken on both sides of, and measured from, the cubic face *a*, are given below.

	b	*c*	*ε*	*ω*	*m*	*ϕ*	
Direct reflection	6° 11′	9° 17′	12° 30′				right.
Schimmer	6° 17′ 6° 25′	9° 24′ 9° 49′	12° 42′ 12° 58′	17° 17′ 17° 16′			
Direct reflection	6° 12′						left.
Schimmer	6° 7′ 5° 50′	9° 17′ 9° 2′	12° 20′ 11° 47′	16° 26′ 16° 20′	25° 7′ 25°	31° 23′	
Mean	6° 10′	9° 22	12° 27′	16° 47′	25° 3′	31° 23′	

Calculated for the following forms.

16° 13′	9° 27′	12° 16′	15° 48′	25° 14′	31° 13′
(13·1·1, +13-13),	$\left(17{\cdot}2{\cdot}2, +\frac{17}{2}-\frac{17}{2}\right)$,	$\left(13{\cdot}2.2, +\frac{13}{2}-\frac{13}{2}\right)$,	(511, +5—5),	(311, +3—3),	(733, $+\frac{7}{3}-\frac{7}{3}$).

The reflections from *ω*, *m* and *φ* were very faint, that from *φ* being the last trace of reflected light which could be seen on turning the crystal. The measurements agree quite well among themselves, considering the method used, and warrant my taking the above symbols according to which fig. 2 is drawn. The form *ω*(511, +5·5) shows the greatest variation, but, as it is a prominent form on the simpler and more perfect crystals, it seems better to regard the variation as due to error in measurement than to take the less probable symbol (922, $+\frac{9}{2}-\frac{9}{2}$) with calculated value 17° 27′. The only other form m′($3\bar{1}1$, —3·3) was quite large and very strongly striated parallel to its combination edge with the cube. The faces gave no reflection but were measured by covering them with glass plates and then measuring on the cube. This was repeated twice giving 24° 49′, 25° 21′, calculated 25° 14′.

In appearance the crystals resemble very closely those of sphalerite while the forms which are common to both are *a*(100, *i*-*i*), *o*(111, +1), *o*′(1$\bar{1}$1, −1), *ω*(511, +5-5) and *m*(311, +3-3).

2. METACINNABARITE.

The specimens of this mineral at my disposal, from the Reddington Mine, Lake Co., California, were from the collections of Prof. G. J. Brush and Mr. C. S. Bement. The mineral is intimately associated with crystallized cinnabar and marcasite. Mr. G. E. Moore first described this species* as an amorphous black sulphide of mercury, distinct in its physical properties from cinnabar. He states that specimens which he examined from the collection of Prof. Brush showed small crystals "whose habit is almost cubical" and "betray in their frequent re-entrant angles a strong tendency to the formation of twins." The specimens at my disposal show crystals up to 4^{mm} in diameter, they are apparently isometric, tetrahedral, but the faces are such that they do not admit of accurate measurement. The habit of the crystals is mostly octahedral with the alternate faces of the plus and minus tetrahedron varying in luster. The faces are usually dull black and rough, giving no reflection, or curved. Measurements on the tetrahedral face could not be obtained. The forms which I have been able to identify are the following, while the measured angles are given in the table below, (322, $\frac{3}{2}$-$\frac{3}{2}$), common, occurring sometimes alone in one set of secants, at times truncating the edges of an apparent octahedron (plus and minus tetrahedron). One specimen contained small crystals of the form (211, 2-2), in combination with small and rough faces of the tetrahedron of the opposite order. On one crystal the faces in one set of secants were quite bright and contained markings and small faces indicating a (*hkl*, *m*—*n*) form; the measurement of the two kinds of edges in the secant, as far as I was able to obtain them, gave for the values of *m* and *n* respectively 1·849 and 1·233, perhaps (975, $\frac{9}{5}$-$\frac{9}{7}$), but as the reflections were not very distinct and could not be repeated on a second crystal it seems useless to assume a symbol for this form. The cubic faces occur very seldom on the specimens examined by me. Twins parallel to an octahedral plane are very common, often repeated as in sphalerite.

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* This Journal, III, iii, 36.

The measured angles are as follows:

$322 \wedge 3\bar{2}\bar{2}$	86° 34′ 86° 52′ 87° 17′	86° 38′
$211 \wedge 112$	36° 54′ 33° 24′ 33° 15′	33° 34′

Although the crystals are poorly adapted for measurement their habit is characteristically isometric tetrahedral, and the measurements as far as made agree with isometric forms. After seeing the specimens at my disposal it seems strange that the name "amorphous sulphide of mercury" should have been so long attached to this mineral.

After carefully cleaning the crystals used for measurement and freeing them as far as possible from attached cinnabar, the specific gravity was taken with great care on a chemical balance, with 7·81 as the result. As the three crystals weighed together only ·1684 grams the result can not be regarded as very accurate, but I thought it would serve to compare with the specific gravity of the amorphous sulphide given by Mr. Moore as from 7·701–7·748.

The crystallographic results taken in connection with those on tiemannite, with which the mineral stands in close chemical relation, leaves little doubt as to the isomorphism of the two minerals, and the isometric character of metacinnabarite, while the intermediate chemical compounds to which the name onofrite has been applied and which are not known in crystals stand intermediate between the two in physical relations.

Relation between the selenides and sulphides of mercury.—As the density which I found for the crystals of tiemannite, viz: 8·19, was greater than that given by other authors (this usually being 7·1–7·4, Blum giving 7·8–7·88), I thought it would be best to take the density of the material from Clausthal, which was all that was at my disposal. The material was quite impure, but after taking the density the volatile selenide was driven off, the density of the residue taken and that of the pure material calculated. I also took the density of three specimens of onofrite from Utah; in these cases, however, the residue was smaller and was regarded as having a density of 2·7. Undoubtedly it was heavier and the true density of the mineral would be correspondingly lower.

All the densities which have been found are the following:

I.	Tiemannite, crystallized, from Utah	8·19
II.	Tiemannite, Clausthal, after deducting 16 per cent of impurities	8·473
III.	Tiemannite, Clausthal, after deducting 39 per cent of impurities	8·305
IV.	Onofrite, Utah, after deducting 1·3 per cent of impurities	7·98
V.	Onofrite, Utah, after deducting 1·6 per cent of impurities	8·09
VI.	Onofrite, Utah, after deducting 2·9 per cent of impurities	8·04
VII.	Metacinnabarite, California, crystallized	7·81
VIII.	Metacinnabarite, California, amorphous, determined by Moore	7·70 7·75

It will be seen that onofrite stands, as it should, intermediate between the selenide and sulphide. No. IV of the above list was analyzed by Mr. Wm. J. Comstock* and consists of 13·7 per cent HgSe and 86·3 per cent HgS. Calculating the density of an isomorphous mixture in the above proportions taking the density of HgSe=8·2 that of HgS=7·8 we obtain 7·85 as against 7·98 observed. Onofrite is therefore physically intermediate between tiemannite and metacinnabarite, and represents an isomorphous mixture of these two isometric molecules. It is strange that the conclusions arrived at by Prof. Brush in the article already referred to, should have been the same, although he based his conclusions on earlier and incorrect determinations of the density of tiemannite.

As to the position which these minerals should occupy in a natural grouping, it seems that they would naturally come into the sphalerite group with which they have many things in common, being simple selenides or sulphides, with mercury replaced in part by zinc or cadmium, crystallizing in the isometric system, tetrahedral, and with strong tendency to twinning parallel to the octahedron.

In closing I take pleasure in expressing my thanks to Prof. Brush and Mr. C. S. Bement for the material which they provided for carrying on this investigation.

Note as to the occurrence of Tiemannite; by Prof. J. E. CLAYTON. Communicated by letter to Prof. Brush, dated Salt Lake City, October 6th, 1884.

The mine is situated above five miles S.W. of Marysvale, two hundred miles south of Salt Lake City. It is on the east face of a mountain slope and near to a profound fault extending north and south. To the east are eruptive rocks including porphyry and trachyte. Underlying the ore beds to the west is quartzyte of unknown thickness, over this about four hundred feet of gray limestone and in the contact between these the Deertrail vein is situated, carrying gold, silver, lead and a little copper. In the upper portions of the limestone the selenide of mercury is found in a bed of shaly limestone fifteen to twenty feet thick. The vein has been traced north and south about one hundred feet along the outcrop and dips into the mountain at an angle of about 15° below the horizon. The ore occurs in masses intermixed with the shaly limestone, crystals being very rare. The accompanying minerals are barite, oxide of manganese, quartz and calcite. The ore bed is overlaid by a yellowish, sandy, lime-shale carrying Subcarboniferous fossils.

Mineralogical Laboratory Sheffield Scientific School, March 28th, 1885.

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* This Journal, III, xxi, 312.

ART. LVIII.—*On the Gahnite of Rowe, Massachusetts*; by ARNOLD GUYOT DANA.

IN some car-loads of pyrite brought to New Haven, Connecticut, from the mines of J. M. Davis & Co., in the town of Rowe, Massachusetts, eight miles east of the Hoosac tunnel, I found some fragments of the mineral gahnite. On visiting the locality I learned that the gahnite occurred on the outer portions of a "vein" or "lenticular mass" of pyrite, of exceptional purity, varying from seven to twenty feet in thickness. The including rock is gneiss and schist. The mine had, at the time of my first visit, reached a depth of 200 feet. The waste heaps afforded a large amount of material and some good specimens, though the hardness of the enclosing rock made it difficult to obtain the crystals unbroken. Part of them were entirely embedded in the pyrite and part seemed to have once lined cavities, most of which had since been filled in by quartz and the rest by chalcopyrite.

The crystals in the quartz were greenish in color and sometimes had a slightly greasy lustre, while those in the pyrite were almost black, but green by transmitted light, and had a high vitreous lustre. These latter, though apparently the most pure, were so filled with minute particles of pyrite that for analysis it was necessary for the most part to use those in the quartz.

The largest crystals had a diameter of three-quarters of an inch, but the majority were much smaller. Their habit was octahedral, with the faces usually built up terrace-like from the alternations of the octahedron with the dodecahedron. Simple dodecahedrons were rare. No other planes were observed, though many crystals were examined. Good examples of the spinel twin were occasionally met with.

The specific gravity taken on a piece of exceptional purity weighing nearly two grams was 4·53.

An analysis of the gahnite, made because of the refractory nature of the substance on half a gram, gave:

	I.	II.	Mean.
Al_2O_3	54·61	55·04	54·83
Fe_2O_3	3·22	2·79	3·00
FeO	3·25	3·49	3·37
MnO	*tr.*	*tr.*	*tr.*
MgO	2·01	1·86	1·93
ZnO	36·91	36·93	36·92
SiO_2 and insoluble residue	·57	·48	·53
	100·57	100·59	100·58

The mineral was decomposed by repeated fusion with $K_2S_2O_7$. The insoluble residue having been filtered off, the zinc was thrown down as sulphide by H_2S in an HCl solution—according to the method elaborated by Mr. Osborne of this laboratory*—then dissolved and re-precipitated as carbonate. The ignited ZnO was examined for iron and the small amount found taken into account. The alumina and iron were twice precipitated as hydroxides with NH_4OH and weighed together. The iron was determined by titration with permanganate of potash, and the alumina obtained by difference. The amount of iron obtained was divided between the protoxide and sesquioxide in such proportion that the oxygen ratio should be as the formula demanded. The magnesium was weighed as pyrophosphate.

Besides the pyrite, which is seldom found in crystals of any size, the chalcopyrite and the quartz, the minerals associated more or less intimately with the gahnite are: thin plates of titanic iron, sometimes an inch across; steel gray rutile, occasionally in good crystals; apatite in small light green crystals; sphalerite; garnet; calcite; a triclinic feldspar in greenish crystals, and epidote.

The epidote occurs in curving, thick columnar forms and mostly in the pyrite. It is nearly opaque and of a greenish gray color passing into ash gray.

An analysis showed that it had the following composition:

	I.	II.	Mean.
SiO_2	38·18	38·23	38·20
Al_2O_3	24·57	24·66	24·62
Fe_2O_3	12·16	13·24	12·20
MnO (two separate portions)	·57	·57	·57
MgO	·12	·14	·13
CaO	21·64	21·54	21·59
Alkalies (one portion)	·37	·37	·37
H_2O	2·15	2·17	2·16
Insoluble residue	·35	·34	·35
	100·11	100·26	100·19

Ca : R : Si = 409 : 935 : 1·272 or nearly 4 : 9 : 12

In this connection it may be interesting to add that during a recent visit to Franklin Furnace, New Jersey, I found the gahnite imbedded in magnetite from the "Trotter" mine. One crystal $\frac{6}{10}$ of an inch in diameter had the planes O, 1, *i* and 3-3 well developed.

Laboratory of the Sheffield Scientific School, April, 1885.

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* Am. Chem. Journ., vi, No. 3.

ART. LIX—*The Genealogy and the Age of the species in the Southern Old-tertiary*; by OTTO MEYER, PH.D.

HAVING for some time been engaged in the study of the Old-tertiary formation of the Southern States, especially of Alabama and Mississippi I have reached the following results:

1. This formation contains so many forms that have not hitherto been made known, that the existing lists, their other faults not considered, can be said to give only a poor picture of this fauna.

2. For the three main localities, Vicksburg, Jackson and Claiborne, which are succeeding beds, a genealogy (see the table beyond) can be made out for many species. They can be traced through two beds or all three of them, either remaining unaltered, or varying somewhat, or varying in such a degree, that different specific names must be used. In other words: many described and undescribed species are most probably connected by descent.

3. Since the discovery of these beds it has been generally accepted, that the "Claibornian" is the oldest and that their succession is as follows: Claiborne (Middle Eocene), Jackson (Upper Eocene), Vicksburg (Oligocene); the existing maps are colored accordingly. This has been done without sufficient reasons and it is even very probable that the succession is just the contrary—Vicksburg the oldest and Claiborne the most recent formation.

As for the new species I hope to be able to describe them soon. I am obliged to name and describe a part of them in the following pages without figures. But most of them are defined, though briefly, yet exactly, by giving the differences from allied known species. I think that a paleontologist collecting at the same locality will be able to recognize them, and this is more than can be said for many species described and figured from this Tertiary.

PART I.

The Genealogical Relations of the Species.

If we have three formations, one above the other, not separated by a geological gap or by long geological times, but apparently deposited during a gradual rising of the coast, we may expect the following. Many of the species will remain unchanged or vary to some extent, others will vary very much. If variations of a species disagree more and more they may become different species. Some species may become extinct or emigrate, others may immigrate. These last points can be determined only by a complete knowledge of the respective faunas. But many of the variations can be recognized with the assistance even of a part of them, such as is represented by our collections. All the conclusions in this essay are based upon material in my possession, collected by me in the localities mentioned. I have used the existing descriptions and figures only for determining the specimens found in the same place, and have not drawn a conclusion nor made a suggestion (marked by [ ]), except by direct comparison of specimens. Thus the table shows only the relations between the materials in my present collection, and future collecting may add many new points.

In tracing out relationships between different species the following considerations were guiding.

Species, which disagree above a certain moderate extent in their embryonic parts, cannot be nearly allied, however similar they may appear.

The differences between related species must be generally of a more quantitative than qualitative nature.

While some of the qualities may differ, perhaps even considerably, most of them must be expected to remain unchanged.

If two related species differ in certain points, it is to be expected that they will vary somewhat in the same points in at least one of the localities.

Very small peculiarities in teeth, striæ, pits, etc., usually not mentioned in descriptions, are sometimes very characteristic of a species and remain constant, when other qualities vary. These little things sometimes give good indications of relationships.

It must not be forgotten that not the animals, but only the shells can be compared, and what may be considered a slight difference in the shell may represent a considerable difference in the animals; or the reverse may be the case. What I deem as too slight a difference to make varietal or specific distinctions, may be thought by other authors of sufficient importance to render these distinctions necessary; or, on the contrary, others may find my distinctions exaggerated. Moreover I may have made, notwithstanding all care, in one case or another entirely wrong relationships. All these considerations may influence every single detail represented in the following table, but in general the relationships here claimed between the three faunas are beyond doubt. From a review of the geological and paleontological evidences *I cannot explain these relations other than by derivation.*

When Conrad described the Vicksburg and Jackson species, he identified very few of them with Claiborne fossils, but founded new species on very small differences. He had often to say "related to . . . from Claiborne." Afterwards he was of the opinion, that the three beds had no species at all in common and gave new names to those which he formerly considered identical. It would be very difficult to defend this hypothesis even if no other species occurred in Jackson than those which he described, but with a better knowledge of the rich Jackson fauna it is impossible. The synonyms in parentheses in the table are the names used by Conrad. The table will explain itself in general and in the following pages only such explanations are made as are necessary. The references to the literature of most of the species can be found in the American Journal of Conchology, 1865, pp. 1–35. The numbers refer to those in the table.

3. From Jackson I have two specimens, which are distinguished from *Discoflustrellaria Bouëi* Lea sp. in being flat and having longer cells. I call them *Discoflustrellaria Jacksonensis.* They may be a variety or different species, but are to be related to the Claiborne form.*

7. *Pecten Lyelli* Lea occurs also in Jackson. I would here call attention to a characteristic mark that Lea does not mention,—four or three teeth on the margin below the large wing.

8. *Pecten Deshaysi* Lea is very similar to *Pecten nuperus* C. To this latter form I relate that species in Vicksburg which Conrad omits from his lists, though it is the most abundant one in that locality. In Hilgard's Geology of Mississippi it is called *Pecten Poulsoni.* I have no typical *Pecten Poulsoni* Morton from St. Stephens, to ascertain whether this name is right or not. At first sight one may be surprised, that I relate these two species, one of which is moderately inflated, while in the Vicksburg species one valve is very ventricose and the other nearly flat. But in this regard *P. Poulsoni* varies considerably. One may pick out valves which are entirely flat, and others which have a relatively large inflation, and the agreement in the ornamentation was of decisive value for me.

Pecten Lyelli and *Pecten Deshaysi* are probably only two different valves of one species.

14. In Jackson occurs a species, *Limopsis radiatus*, n. sp., agreeing with *Lim. obliquus* Lea sp. from Claiborne, but somewhat larger and having radiating ribs. The latter difference is so striking, that I should not have related the two species to each other, except perhaps by a [ ], had I not a specimen of *L. obliquus*, which shows the same ribs. Though they are less distinct they are formed in the same manner as in the Jackson form by nodules on the concentric striæ.

16. The two Claiborne species, *Leda plicata* Lea sp. and *Leda*

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* The danger of misrepresenting Mr. Meyer, in attempting to remove his German idioms, leads us to leave them as written.—Eds.

media Lea sp. have the following differences. *L. plicata* is compressed, very inaequilateral; the concentric ribs continue over its anterior portion and on this portion there is a radiating furrow. *L. media* is more inflated, the beaks are medial, the concentric ribs look as if erased on the anterior portion and there is no furrow. In Jackson a species is not rare which may be called *Leda mater*. I have also a specimen of it from Claiborne. This species has the inequilateral form of *L. plicata;* the position of the beak however is not quite constant and is sometimes a little more medial. It is inflated like *L. media,* but some specimens are more compressed. The folds on the surface continue generally over the anterior portion, but become less distinct there and sometimes even vanish. A slight furrowing of the anterior portion may be noticed in most of the specimens, but not in all. In short, *Leda mater* in Jackson stands between *L. plicata* and *L. media;* it varies in certain features, and the same features constitute in a developed form the differences between the two species in Claiborne. From these facts the conclusion might be deduced, that the two species are also derived from *L. mater.*

17 and 18. *Astarte sulcata* Lea occurs in Jackson with more numerous concentric ribs and seems to be generally stouter than in Claiborne; this may justify a varietal name var. *Jacksonensis.* It is very singular that the same differences exist between *Astarte Nicklini* Lea and *Astarte parilis* C.?,* so that we find two similarly looking species of one locality altered in the same manner in the other place.

19. *Astarte* (Micromeris) *parva* Lea occurs also in Vicksburg in a form which is broader and less ribbed, var. *Vicksburgensis.* A specimen from Jackson is more similar to the Claiborne form.

22. In Jackson occurs *Venericardia diversidentata*, n. sp., similar to *Vener. rotunda* Lea, but with a larger beak, and the tooth of the left valve horizontal, while in the Claiborne species it rises obliquely. Though one of the Claiborne specimens has also a large beak, the differences appear to me of such importance as to require a new specific name. The relation to *Vener. rotunda* is so obvious, that for instance in Hilgard's Geology of Mississippi it is enumerated under this name. In the young specimens of the Claiborne species the tooth has nearly, or perhaps entirely, the same form as in the Jackson species.

23. *Venericardia parva* Lea occurs in Jackson in a smaller form with straighter lateral margins. These two qualities are not constant in Claiborne, and the distinction is properly made by a varietal name, var. *Jacksonensis.*

24. A specimen from Claiborne resembles *Venericardia parva* Lea, but is very distinct by being still smaller, very much inflated, having a much larger beak and less nodulous ribs. It may be called *Venericardia inflatior.* The same form is also rare in Jackson in a variety with straighter lateral margins, var. *Jacksonensis.*

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* There exists no description of this species and from the poor figure I can only guess this determination.

27. I have *Lucina Mississippiensis* C. only from Jackson and this is the only exception to the rule, to compare only specimens. But this Lucina is very characteristic and agrees exactly with the figure and description of the Vicksburg species.

30. A species of Lucina is common in Jackson, and not very rare in Vicksburg, which is suborbicular and rather flat. Lateral teeth are obsolete; beak medial, acute and turned anteriorly. Posterior margin is truncated and posterior extremity subcanaliculated. It is covered with concentric striæ, less numerous on the posterior side, which have a tendency to become prominent on the carina and near the margins. Margin entire. This species is not named as it may perhaps be identical with Conrad's *Lucina Claibornensis*,* although Conrad says in his description "inequilateral." He describes this species from Claiborne, but from a "group at the base of Claiborne Bluff, belonging to an older division of the Eocene than the Claiborne group above."

31. *Cardium Nicolleti* C., from Jackson, and *Cardium diversum* C. from Vicksburg have only quantitative differences in the ornamentation.

33. The genus Cytherea seems here to vary very much. It is not only difficult to find out relations between the species, but even to separate the species, especially in Claiborne, when the material of the lowest and highest Claibornian (see part II) is mixed. In Jackson the genus is rarest and my material from this locality poor. One perfect specimen from Jackson, *Cytherea Jacksonensis*, n. sp., agrees with *Cytherea Hydi* Lea, but has a narrower hinge. The size of the hinge in Claiborne, however, is not quite constant.

35. A rather common Tellina in Jackson is a larger and stouter variety, var. *robusta*, of a Vicksburg species, which I determined as *Tellina Vicksburgensis* C. A young Jackson specimen has the same form as one of the stouter Vicksburg specimens.

36. In Jackson occur fragments, which seem to differ merely in size from *Periploma Claibornensis* Lea sp., which species also is known only in these fragments. The Jackson form may be called var. *parva*.

37. In Jackson occurs a species of Mactra, which is almost equilateral, but otherwise does not differ from *Mactra pygmaea* Lea, from Claiborne. As the forms vary in both localities they are most probably to be related. The Jackson specimens are very similar or identical with a species in Vicksburg, which is perhaps what Conrad called *Mactra funerata*.

38. A new species, *Mactra inornata*, occurs in Jackson. It is small, somewhat flattened, inequilateral and has a rather solid shell. The margin is entire, the lower margin rather straight. Concentric striæ on the extremities are seldom noticeable, because the surface is mostly water-worn. In a specimen from Claiborne I cannot find any difference. A specimen from Vicksburg is relatively higher.

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* Am. Jour. Conch., 1865, p. 146.

39. A Corbula in Jackson differs from *Corbula gibbosa* Lea in having less distinct concentric ribs and a much smaller beak. The last difference is important enough to justify a new name *Corbula Willistoni*,[*] but otherwise the details are alike.

40. *Corbula bicarinata* C. from Jackson differs from *C. Murchisoni* Lea in having the concentric ribs somewhat more numerous and the umbonial carina less distinct, but this variation is slight.

41. *Corbula densata* C. from Jackson has indeed, as Conrad says, a shorter form and a more rounded base than *C. Alabamiensis* Lea, but there are quite a number of specimens of almost the same appearance in Claiborne, which I tried in vain to separate specifically from the elongated forms. So the stout specimens can be considered only a variety.

43. From Vicksburg and Claiborne I have a Dentalium, which agrees with my specimens of *Dent. microstria* Heilpr.[†] from Wood's Bluff. One of the Claiborne specimens has the posterior aperture complete, showing an emargination and opposite to it a fissure. Although Heilprin in his description says "posterior aperture entire, there being no fissure," I have little doubt that it is the same species and that he described an incomplete aperture. The species is too rare and occurs too fragmentarily to enable me to give a sure representation of its variation.

44. A small, smooth, even somewhat polished Dentalium, occurring in Vicksburg and Jackson, is distinguished from all other American species by being compressed, the section showing about the form of an egg. It resembles remarkably that species from the German Oligocene, which I described as *Dentalium compressum*.[‡] To indicate this relation it may be called *Dentalium subcompressum.*

45. In Claiborne occurs a Dentalium, which has not been described, though fragments of it are not rare. The shell is solid, smooth without any ribs; section circular. The posterior aperture is formed very characteristically. The margin is notched twice; the notches are opposite, deep and almost of the same size as the remaining two opposite prominences of the margin. From within, a little tube rises. This species may be called *Dentalium Leai* in honor of I. Lea, whose "Contributions to Geology" I consider as the best part of the American Tertiary literature. In Jackson occurs a species, fragments of which cannot be distinguished from the Claiborne form. The posterior aperture however, although showing also the little tube, has only one of the notches, which moreover is less deep. It may be called *Dentalium Danai.* As the other notch is at least indicated by a slight emargination, the species are to be related to each other.

46. In Vicksburg and Jackson occur quite a number of species of Cadulus. One of them in Jackson, *Cadulus Jacksonensis*, n. sp., is the largest one. The inflation is near the anterior

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[*] In honor of my friend Dr. S. W. Williston, U. S. Geological Survey.

[†] Proc. Ac. Nat. Sc. Philad., 1880, p. 375.

[‡] Jahresb. d. Senckenb. Naturf. Gesellsch., Frankfurt a. M., 1882–3, p. 258.

aperture. Aperture and section are not circular but ovate, the species, however, is not as much depressed as *Cadulus depressus* Meyer* from Claiborne. The most characteristic is the posterior aperture. By four notches or fissures this end is divided into four turret-like appendages, similar to what Lea describes in his *Dentalium turritum.* Of these four prominences only the opposite ones are alike; two are small and simple, the other two broad and slightly emarginate in the middle. The largest species in Vicksburg has apparently the same form and almost the same aperture, but in the emargination of the two large appendages there seems to be a difference, and the specimens are smaller than in Jackson. It may be considered either a variety or a different species, and may be called *Cadulus Vicksburgensis.*

What Lea described as *Dentalium turritum* is apparently a fragment of a large Cadulus with well preserved posterior aperture, and not a fragment of a Dentalium with "accidental" aperture, as Conrad once suggested. As Lea, who observed very exactly, writes "aperture round" it is probably not identical with the strongly compressed *Cad. compressus* Meyer. I found of the latter species, unfortunately, no well preserved posterior termination, and not having seen Lea's type-specimen I cannot have a decided opinion about the relation of the Jackson to the Claiborne species.

47. From Claiborne I have two species of Teinostoma. Both are small, the umbilical region is completely covered by a callus, which has a tendency to spread over the whole shell. Where it does not cover the shell, revolving lines are to be noticed. The two species differ very much, as one of them, *Teinostoma subrotunda,* n. sp., has the last whorl with an almost imperceptible angle, while the other, *Teinostoma angularis,* n. sp., is extremely carinated. In Jackson occurs *Teinostoma Verrilli,* n. sp., which differs from *Tein. subrotunda* in having a more distinct angle and showing no revolving lines. In a young specimen from Vicksburg I find no difference from the young Jackson form.

50. *Solarium Henrici* Lea, from Claiborne agrees with *Solarium bellastriatum* C. from Jackson, but in the latter species there are two revolving, impressed lines directly above the suture very distinctly developed, while in the Claiborne form they are only indicated or quite obsolete. At the base of *S. Henrici* we find one distinct line around the umbilicus and an indistinct one along the margin; at the base of the Jackson species the umbilical line is very much impressed, along the margin there are two distinct lines and one more line on the middle of the whorl. Some of the Jackson specimens show indistinct traces of more longitudinal lines; these other revolving lines are fully developed in the Vicksburg species, *Solarium triliratum* C.

This relation between the three forms is one of the best illustrations of evolution, which can here be brought forth. The three Solaria appear different enough to justify specific names. On the other hand the resemblance is too evident to be overlooked. The Jackson form may be said to stand exactly in the middle and without this connecting link the difference between the Vicksburg and the Claiborne species might appear too great to indicate their derivation.

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* Proc. Ac. Nat. Sc. Philad., 1884, p. 111.

51. *Turritella carinata* Lea varies to such an extent in Claiborne, that the specimens there disagree at least as much from each other as they are different from the forms in Jackson and Vicksburg. For this reason I prefer not to use varietal names for these two localities.

52. *Turritella lineata* Lea, from Claiborne, increases in width much more rapidly than *T. alveata* C. from Jackson, where the first whorls are flat and only the older whorls become rounded. But these species are perhaps to be related to each other.

56. The Claiborne species *Natica parva* Lea reaches in Jackson a considerable size. The umbilicus seems to be a little smaller and also the broad emargination of the inner lip near the umbilicus seems to be slighter, but I will not propose a special varietal name. A characteristic of *Natica parva* is that the upper part of the whorls is broadly canaliculated. This quality is obsolete in a new species from Vicksburg, *Natica decipiens*. As form and umbilicus, however, are alike, and smaller markings agree, for instance a callous prominence on the posterior part of the mouth, I relate them to each other.

59. Besides *Eulima aciculata* Lea sp., there is in Claiborne a very rare species of Eulima, as highly polished and of about the same form, which is characterized by an indistinct suture. The same species is less rare in Jackson and Vicksburg, at least I cannot detect specific differences. *Eulima exilis* Gabb, from Texas, which I do not have, seems to have the same indistinct suture, and is perhaps identical.

61. In Jackson occurs a species nearly allied to *Distortrix septemdentata* Gabb from Texas. It differs in having the canal somewhat reflected, being more callous on the inner lip, having more prominent varices and more distinct transverse ribs. It may be called *Distortrix Jacksonensis*. This species is probably to be related to *Distortrix crassidens* C. from Vicksburg.

65. In Jackson and Vicksburg occurs a species, *Fusus Boettgeri*,* n. sp., closely allied to *Fusus subtenuis* Heilpr. from Wood's Bluff. The only essential difference seems to be that the Jackson form has the inner lip covered by callus on which there are numerous little prominences, while this callus does not exist in *F. subtenuis*.

68. A species in Jackson, *Turbinella humilior*, n. sp., differs from *Turbinella protracta* C. in being shorter and stouter and having a somewhat reflected canal. The two species agree otherwise; for instance the following marks at the mouth are common to both. On the inner lip there are three little prominent folds;

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* In honor of my friend, the able and careful naturalist, Oscar Boettger, in Frankfurt a. M.

on the posterior part is a callous prominence; in a certain rather large distance from the outer lip there are seven elevated striæ within; at the beginning of the canal is a tooth-like prominence.

In the younger specimens from Jackson the canal is straiter than in the older ones.

69. In Jackson occurs a species, *Fulgur filius*, n. sp., which has the form of *F. Mississippiensis* C. from Vicksburg. The coarse part of the sculpture is also similar, but the surface is covered with fine, closely set, elevated revolving lines. In the largest of my Vicksburg specimens the following can be seen: In the youngest reticulated whorl there are only the large revolving lines, then a small line appears in the middle of the large ones and finally one more line appears in the interstices. If we imagine this process repeated twice more, we obtain the finely striated surface of *F. filius*, and indeed this same process can be traced along the whorls of the Jackson form, so that we can say, the young *F. filius* repeats the old *F. Mississippiensis.*

72. A Marginella in Jackson agrees essentially with specimens from Claiborne, which I determined as *Marg. incurva* Lea, but seems to be generally larger and much inclined to deposit callus on the posterior part of the mouth. It may be called *var. Jacksonensis.*

74. *Mitra dumosa* C., from Jackson, is more slender and ornamented than *M. pactilis* C., from Claiborne, but both qualities vary in both places and *M. dumosa* cannot be considered more than a variety.

75. One of the most difficult genera is Oliva. On one side the species vary very much, especially in form. Any doubt about this is removed by two specimens of a common species in Jackson, where the color is preserved. On the other hand it may be that different species in the fossil state are distinguished only by small differences.

I relate three species to each other, one from Claiborne, determined as *Oliva gracilis* Lea, the above mentioned one from Jackson, which is generally stouter, and *Oliva Mississippiensis* C., from Vicksburg, which is larger and again stouter and where the main inflation is generally somewhat higher. The Jackson species may be called *Oliva media.*

76. A specimen from Vicksburg, which may be Conrad's *Cancellaria funerata*, resembles much a specimen from Jackson (not the common Cancellaria). A disagreement in the third embryonic whorls, however, may indicate a different origin.

77. The Vicksburg species *Terebra divisura* C. is rather common in Jackson, but from Claiborne I have only one imperfect specimen. The variation seems to be mainly in the distinctness of the line below the suture.

78. The genus Pleurotoma, of which numerous species occur in the three deposits, must have varied or migrated very much at this time, or both. Two species look similar, *Pleur. Lonsdali* Lea from Claiborne and a species in Vicksburg (*Pleur. Mississip-*

piensis C.?). But my material is not complete enough to allow a conclusion in regard to a relationship.

In Jackson occurs a species, *Pleurotoma exsculpta*, n. sp., which differs from *Pleur. tenella* C., from Vicksburg, in having the ornamentation, especially the transverse striæ, more distinctly worked out and the canal shorter. The length of the canal of *P. tenella*, however, varies a little and I consider the two species to be related.

79. *Conus tortilis* C. and *Con. alveatus* C. are only slight variations of *Conus sauridens* C.

80. In Vicksburg occurs a new species, *Conus protracta.* It approaches in its form the genus Conorbis. The lower part is almost like that of *Conus sauridens* C., but it is a smaller species. The spire is elevated, forming the third part of the shell, is without revolving lines and has one or two smooth embryonic whorls more than *C. sauridens.* In Jackson occurs a similar form but with revolving lines on the spire, *Conus Jacksonensis*, n. sp. Probably both species are to be related to each other.

81. A species in Jackson, *Actæon annectens*, n. sp., is similar and related to *Act. punctatus* Lea, but it is smaller, has a more regularly rounded form than the Claiborne species generally has, and the fine transverse striæ are less closely set. The largest specimen moreover has an indistinct second fold above the larger first one.

84. From Claiborne I have a complete specimen of Cylichna, which belongs to the subgenus Volvula. A similar or identical species occurs in Jackson. After a comparison with my specimens of *Bulla radius* Desh. I am inclined to identify the American and French species. What Gabb describes as *Volvula Conradiana* from Texas must be nearly allied or identical.

In the table *C.* stands for *Conrad*, *Mr.* for *Meyer*.

TABLE SHOWING THE SUCCESSIONAL RELATIONS OF THE VICKSBURG, JACKSON AND CLAIBORNE SPECIES. THE SYMBOL > SIGNIFIES DECREASING IN ABUNDANCE IN THE DIRECTION TOWARD WHICH IT POINTS, AND [ ] THAT THE RELATIONS ARE DOUBTFUL.

	VICKSBURG.	JACKSON.	CLAIBORNE.
		1. Foraminifera.	
1	Nodosaria obliqua *L.* sp.	Nodosaria obliqua *L.* sp.	Nodosaria obliqua *L.* sp.
		2. Bryozoa.	
2		Lunulites interstitia *Lea* sp.>	Lunulites interstitia *Lea* sp.
3		Discoflustrellaria Bouéi *Lea* sp. >	Discoflustrellaria Jacksonensis *Mr.*
		3. Corals.	
4		Turbinolia pharetra *Lea.* <	Turbinolia pharetra *Lea.*
5		Endopachys Macluri *Lea* sp.	Endopachys Macluri *Lea* sp.
6		Platytrochus nanus *Lea* sp.	Platytrochus nanus *Lea* sp.

	VICKSBURG.	JACKSON.	CLAIBORNE.
		4. Lamellibranchiata.	
7		Pecten Lyelli *Lea.* >	Pecten Lyelli *Lea.*
8	Pecten (Poulsoni *Morton* ?)>	Pecten nuperus *C.* >	Pecten Deshaysi *Lea.*
9	Avicula Claibornensis *Lea.* (A. argentea *C.*)	Avicula Claibornensis *Lea.*	Avicula Claibornensis *Lea.*
10	Arca (Byssoarca) Mississippiensis *C.*	Arca (Byssoarca) Mississippiensis *C.*	
11	Arca (protracta *C.* ?) sp.	Arca rhomboidella *Lea* var.	Arca rhomboidella *Lea.*
12	Pectunculus arctatus *C.*	Pectunculus arctatus *C.* (var. ?)	Pectunculus arctatus *C.* (var.?)
13		Pectunculus Broderipi *Lea.*	Pectunculus Broderipi *Lea* var. filosus *C.* (*P.* filosus *C.*)
14		Limopsis radiatus *Mr.*	Limopsis obliquus *Lea* sp.
15	Nucula ovula *Lea* var. Vicksburgensis *C.* or? Nucula Vicksburgensis *C.*	Nucula ovula *Lea* (var. ?)	Nucula ovula *Lea.*
16		Leda mater *Mr.*	> [Leda plicata *Lea* sp.] > Leda mater *Mr.* (var. ?) [Leda media *Lea* sp.]
17		Astarte sulcata *Lea* var. Jacksonensis *Mr.*	Astarte sulcata *Mr.*
18		Astarte Nicklini *Lea.* var. parilis *C.* (*A.* parilis *C.*)	Astarte Nicklini *Lea.*
19	Astarte parva *Lea* var. Vicksburgensis *Mr.*	Astarte (Micromeris) parva *Lea.*	Astarte (Micromeris) parva *Lea*
20	Alveinus minutus *C.*	< Alveinus minutus *C.* >	Alveinus minutus *C.*
21		Venericardia planicosta *Lam.*	Venericardia planicosta *Lam.*
22		Venericardia diversidentata *Mr.*	Venericardia rotunda *Lea*
23		Venericardia parva *Lea* var. Jacksonensis *Mr.*	< Venericardia parva *Lea.*
24		Venericardia inflatior *Mr.* var. Jacksonensis *Mr.*	Venericardia inflatior *Mr.*
25	Crassatella Mississippiensis *C.*	?	Crassatella alta *C.*
26		Crassatella protexta *C.* var. flexura *C.* (*Cr.* flexura *C.*)	Crassatella protexta *C.*
27	Lucina Mississippiensis *C.*	Lucina Mississippiensis *C.*	
28	Lucina perlevis *C.*	Lucina perlevis *C.*	
29		Lucina papyracea *Lea.*	Lucina papyracea *Lea.*
30	Lucina sp.	Lucina sp.	
31	Cardium diversum *C.*	Cardium Nicolleti *C.*	
32		Cytherea minima *Lea.*	Cytherea minima *Lea.*
33		Cytherea Jacksonensis *Mr.*	< Cytherea Hydi *Lea.*
34	[Cytherea sobrina *C.*]		Cytherea comis *Lea.*
35	Tellina Vicksburgensis *C.* <	Tellina Vicksburgensis *C.* var. robusta *Mr.*	
36		Periploma Claibornensis var. parva *Mr.*	Periploma Claibornensis *Lea.*
37	Mactra (funerata *C.*?)	Mactra (funerata *C.* var. ?)	Mactra pygmæa *Lea.*
38	Mactra sp.	Mactra inornata *Mr.*	Mactra inornata *Mr.*
39		Corbula Willistoni *Mr.* <	Corbula gibbosa *Lea.*
40		Corbula Murchisoni *Lea* var. bicarinata *C.* (C. bicarinata *C.*)	Corbula Murchisoni *Lea.*
41		Corbula Alabamiensis *Lea* var. densata *C.* (C. densata *C.*)	Corbula Alabamiensis *Lea.*

	VICKSBURG.	JACKSON.	CLAIBORNE.
		5. Glossophora.	
42	Dentalium alternatum *Lea.* (D. Mississippiensis *C.*)	Dentalium alternatum *Lea.*	Dentalium alternatum *Lea.*
43	Dentalium microstria *Heilpr.?*		Dentalium microstria *Heilpr.?*
44	Dentalium subcompressum *Mr.*	Dentalium subcompressum *Mr.*	
45		Dentalium Danai *Mr.*	Dentalium Leai *Mr.*
46	Cadulus Vicksburgensis *Mr.*	Cadulus Jacksonensis *Mr.*	[Cadulus compressus *Mr.*]
47	Teinostoma Verrilli *Mr.*	Teinostoma Verrilli *Mr.*	Teinostoma subrotunda *Mr.*
48		Solarium bilineatum *Lea.*	Solarium bilineatum *Lea.*
49		Solarium ornatum *Lea* var. acutum *C.* (S. acutum *C.*)	Solarium ornatum *Lea.*
50	Solarium triliratum *C.*	Solarium bellastriatum *C.*	Solarium Henrici *Lea.*
51	Turritella carinata *Lea.* (*T.* Mississippiensis *C.*)	Turritella carinata *Lea.*	Turritella carinata *Lea.*
52		[Turritella alveata *C.*]	Turritella lineata *Lea.*
53	Trochita trochiformis *Lea.*	Trochita trochiformis *Lea.* (*T.* alta *C.*)	Trochita trochiformis *Lea.*
54		Hipponyx pygmæa *Lea*	Hipponyx pygmæa *Lea.*
55	Sigaretus Mississippiensis *C.*	Sigaretus Mississippiensis *C.*	Sigaretus striatus *Lea* sp.
56	Natica decipiens *Mr.*	Natica parva *Lea.*	Natica parva *Lea.*
57	[Natica (semilunata *Lea* ?)]	Natica semilunata *Lea*	Natica semilunata *Lea.*
58	[Natica Vicksburgensis *C.*]	Natica permunda *C.*	
59	Eulima sp.	Eulima sp. >	Eulima sp.
60		Rostellaria Lamarcki *Lea* (R. staminea *C.*) >	Rostellaria Lamarcki *Lea.*
61	Distortrix crassidens *C.*	[Distortrix Jacksonensis *Mr.*]	
62		Pseudoliva pyruloides *Lea* sp. var. perspectiva *C.* (P. perspectiva *C.*) >	Pseudoliva pyruloides *Lea* sp.
63	Buccinum Mississippiensis *C.* >	Buccinum Mississippiensis *C.*	
64	[Fusus altilis *C.*]	Fusus sp.	[Fusus spiniger *C.*]
65	Fusus Bœttgeri *Mr.* <	Fusus Bœttgeri *Mr.*	
66		Clavella humerosa *C.*	Clavella raphanoides *C.*
67	Turbinella perexilis *C.*	[Turbinella perexilis *C.?*]	
68	Turbinella protracta *C.*	Turbinella humilior *Mr.*	
69	Fulgur Mississippiensis *C.* sp.	Fulgur filius *Mr.*	
70		Voluta (Scapha) Parkinsoni *Lea* (Caricella polita *C.*)	Voluta (Scapha) Parkinsoni *Lea.*
71		Marginella semen *Lea.*	Marginella semen *Lea.*
72		Marginella incurva *Lea?* var. Jacksonensis *Mr.*	Marginella incurva *Lea?*
73	Mitra conquisita *C.*	Mitra conquisita *C.* (M. Mellingtoni *C.*)	
74		Mitra pactilis *C.* var. dumosa *C.* (M. dumosa *C.*) >	Mitra pactilis *C.*
75	Oliva Mississippiensis *C.*	Oliva media *Mr.*	Oliva gracilis *Lea ?*
76	[Cancellaria (funerata *C. ?*)]	Cancellaria sp.	
77	Terebra divisura *C.*	Terebra divisura *C.*	> Terebra divisura *C.*
78	Pleurotoma tenella *C.*	Pleurotoma exsculpta *Mr.*	
79	Conus sauridens *C.* (C. alveatus *C.*)	Conus sauridens *C.* (C. tortilis *C.*)	> Conus sauridens *C.*
80	[Conus protracta *Mr.*]	Conus Jacksonensis *Mr.*	
81		Actæon annectens *Mr.*	Actæon punctatus *Lea.*
82		Actæon lineatus *Lea.*	Actæon lineatus *Lea.*
83		Cylichna Dekayi *Lea* (var. ?)	Cylichna Dekayi *Lea.*
84		Cylichna confr. radius *Desh.*	Cylichna confr. radius *Desh.*

ART. LX.—*On Meteoric Iron from Trinity County, California;* by CHARLES UPHAM SHEPARD.

FOR my knowledge of the meteorite here described I am indebted to Col. Joseph Willcox, of Philadelphia, who incidentally mentioned to me last autumn that he had seen some years ago a metallic mass at Holmes' Hole, Mass., brought from California, that he suspected to be of meteoric origin. It was in the possession of Captain C. W. Davis, who procured it ten years ago at Canyon City, in Trinity County. Through the kindness of Mr. A. F. Crowell of Wood's Holl, a few grams were obtained from Captain Davis for examination and analysis; the result of which has been that the meteoric origin, at first regarded as doubtful, has been established.

The first portions that were detached had the appearance of pure limonite; but were afterwards proven to contain minute particles of nickeliferous iron, whereby small fragments were readily attracted by the magnet. The thickness of the crust affording this limonite must have been at least a tenth of an inch; whence it may be inferred, that the meteorite had originated in a very ancient fall. The specific gravity of the limonite was between 3·81 and 4·04. It was compact, but yielded to pulverization, with exception of occasional very fine metallic grains, that flattened slightly by extreme pressure under the pestle. The application of the magnet took up more than half of this powder, which principally consisted of the limonite. It was thus found to be impossible to separate it from the metallic portion. An approximate separation of the two substances, however, was effected by HCl in the cold; and though the combination of them was not uniform, the nickel-iron was determined in one instance to be at least 10 per cent.

Two small fragments of the nearly unaltered interior were supplied for analysis. In these the coarsely grained crystallization was apparent, affording cleavable crystals of the octahedral form, similar to what is found in the Putnam Iron, that of Cocke County and others. The specific gravity of these fragments was 7·1, which is less than the average of meteoric irons, a circumstance to be expected from slight adhesions of hydrated peroxide of iron. To the same reason also is ascribable the considerable loss in the subjoined analysis:

Iron	88·810	
Nickel	7·278	
Cobalt	0·172	
Phosphorus	0·120	= 96·380

For want of material no search was made for tin, copper, or manganese. No sulphur was present in the portions examined. The weight of the mass is nineteen pounds. Its shape is oval, somewhat flattened, with numerous elongated depressions.

Charleston, S. C., April 16, 1885.

ART. LXI.—*The Potsdam Group East of the Blue Ridge at Balcony Falls, Virginia*;* by H. D. CAMPBELL.

BALCONY FALLS is the name given to a succession of rapids in the gorge through the Blue Ridge by which the James River finds its way from the valley to Piedmont, Virginia. There is no other locality in Virginia where the Potsdam formation is better exposed than at this point. All of its strata are cut through by the river. The accompanying map and section are designed to throw a clearer light upon the topography and geological structure of the region.

The Blue Ridge has been here sculptured into seven ridges, the middle one of which is the most clearly defined and alone has a granite axis. This is the Blue Ridge proper. On the map it is called Rocky Row on account of a very bold escarpment of sandstone upon its southeast face. The three ridges lying northwest of it are each crested with sandstone, and have been formed by the disintegration and washing away of the intervening slates. As seen from the river they appear as peaks with depressions between them. The ridges lying southeast of Rocky Row run rather obliquely across the beds of sandstone, and the intervening ravines have been formed by the erosive power of streams several miles in length, such as Matt's Creek and Snow Creek.

Geology.—The section is meant to be somewhat general, and hence the local displacements are left out, which makes the strata appear thicker than they are in reality. It represents an immense broken arch, or anticline, of Potsdam sandstones and slates, followed to the southeast by a trough or syncline of the same.

For about a mile after entering the gorge through the mountains the James River runs almost at right angles to the strike of the strata. Here and there it has washed away the softer slates and caused local displacements of the sandstones on either side, its waters having for a long time been dammed back by the lowest heavy bed of Potsdam sandstone, which is very hard and durable. Where the river crosses this ledge are the rapids known as Big Balcony Falls. Before the canal was built (along the bank of which the Richmond and Alleghany Railroad now runs), the ledge of sandstone projected considerably beyond the margin of the river, and was known as "Balcony Rock," hence the name of the falls. For about a mile after passing Balcony Rock the river runs obliquely across the strike. By its erosive power, aided by a fissure, and probably by ice also, it has worn its channel deep into the underlying

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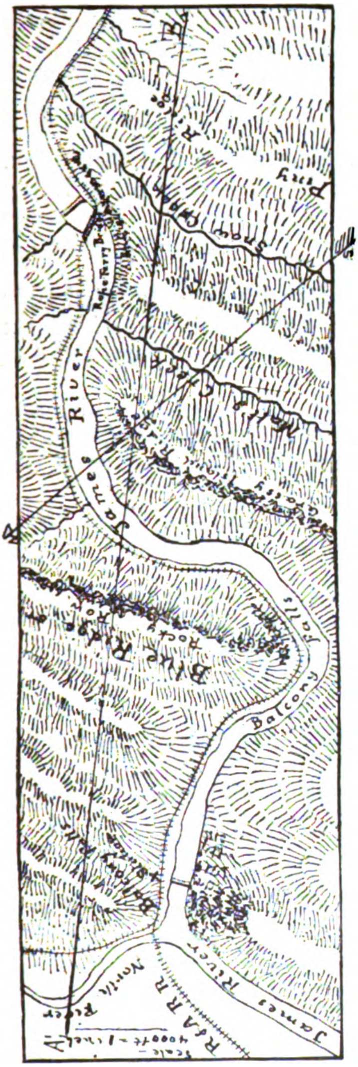
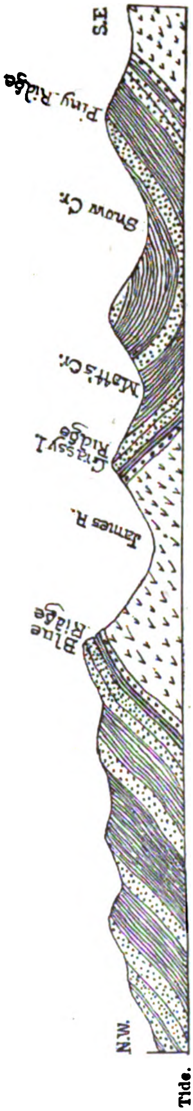
* A short paper upon this subject appeared in this Journal, Sept., 1884.

Archæan rocks, consisting of granulite, syenite and rocks of a gneissoid character. The river then leaves the mountains about at right angles.



Map of the James River Gorge at Balcony Falls, Virginia.



Scale, 4,000 feet = 1 inch.—Vertical Section along the line A–B on the Map.

The sandstones and slates from these Archæan rocks to the western limit of the gap have been classed as Potsdam or Lower Cambrian. Starting from the Archæan axis of the

Blue Ridge and proceeding northwestward up the river we cross the following series of beds:

No. 1 is a bed of conglomerate composed of sand, rounded quartz pebbles, fragments of feldspar and epidote and other material more or less water-worn. This bed is immediately followed by several beds of slates and conglomerate sandstones which have evidently been much altered by heat from the subjacent igneous rocks. The aggregate thickness of these beds is above 120 feet.

No. 2 is a heavy mass of sandstone about 360 feet thick. It consists of two varieties. The lower bed is a hard gray quartzite and is the material of the Balcony Rock. The upper bed is of a grayish and purplish color and finely conglomeritic in texture.

No. 3 consists of dark colored slates with interstratified beds of specular iron ore of low grade, having pebbles of quartz disseminated through them. The thickness of these slates is about 500 feet.

No. 4 is a hard bluish sandstone 150 feet thick, which has been locally displaced near the river, forming several waves that are conspicuous from the railroad. This feature is not represented on the section.

No. 5 is a heavy bed of bluish and greenish slates about 700 feet in thickness. They have been considerably warped and contorted.

No. 6 consists mostly of a brownish gray sandstone with very regularly jointed structure—90 feet thick.

No. 7 is made up of numerous thin beds of slate which produce a variety of shades of color from nearly white and yellow to dark brown. The coloring is produced by iron ore which encrusts many of the thin beds. The thickness of these slates is 120 feet.

No. 8 is the sandstone that constitutes the type of this formation. It consists here of two hard beds of gray sandstone with a more brittle bed intervening. The two hard beds carry numerous markings at right angles to the stratification, supposed to be borings of a worm called *Scolithus linearis.* These three beds, together with some more brittle sandstones underlying them, measure 350 feet. We have now arrived at the entrance of the gap. If we go away from the banks of the rivers some distance we shall find about 600 feet more of sandstone and friable slate before we get to the limit of the Potsdam formation.

Passing now to the eastern slope of the Blue Ridge we find similar beds of sandstone and slate which have been hitherto classed as Archæan by Professors Wm. B. Rogers, J. L. Campbell and others, and have been spoken of as lying unconformably beneath the Potsdam sandstones and slates of the western slope. In Macfarlane's Railway Guide (1879, p. 182) we find the following note by Professor Rogers: "About twenty miles northwest of this point (Lynchburg) by canal or road, we enter the gorge by which the James River traverses the Blue Ridge, where are exposed fine sections of Archæan rocks, A and B, and of the Cambrian, Primal 2*a*, resting unconformably on the western slope of the former, and occupying the flanking ridges which adjoin the valley."

It is with diffidence that I offer my views as opposed to these, making (as seen in the section) an anticline here instead of unconformability; and yet I feel confident that the highly metamorphosed condition of all the rocks east of the Archæan axis, and the hurried review of this locality, led these geologists to place these sandstones and slates as Archæan, and that if the facts which I shall present had been known our views would coincide.

The evidences in support of the section I have drawn are as follows. Rocky Row on the north side of the river is capped with a hard sandstone of a grayish color dipping gently toward the northwest. Grassy Island Ridge, on the south side of the river, is capped with a sandstone of similar appearance, though not so thick, dipping about 40° S.E. Each of these beds of sandstone is underlaid by a brownish decomposing slate, and a bed of coarse conglomerate which lies upon the Archæan rocks. To the N.E. of the river about four miles and again to the S.W. about one mile these strata seem to connect and make a complete anticline. But this might seem to be the case where there is unconformability and hence we need stronger proof.

In all of the heavy beds of sandstone in the Potsdam group of the Blue Ridge above the lowest, *Scolithus* borings are found, varying in abundance in different localities, and being always more numerous in the higher beds. These markings have determined the age of the rocks along the western slope, together with their stratigraphical position. They occur here only in the upper beds, No. 8; but at White's Gap some miles N.E., they occur in abundance in the next lower bed of sandstone. Going now east of the axis of the Blue Ridge and examining the sandstones along the ridge between Matt's Creek and Snow Creek we find unmistakable *Scolithus* borings. These sandstones are conformable with that on Grassy Island Ridge. Proceeding up Matt's Creek we cross two of these beds, each carrying Scolithus borings. Between them lie heavy beds of slate, and in the first of these is found a bed of hematite ore similar to that mentioned above as occurring on the western side of the Blue Ridge and locally known as "block ore" on account of breaking readily into cubical and rectangular masses. This variety of ore in Virginia seems to be characteristic of the Potsdam formation. Cresting the ridge on the left, in ascending Matt's Creek near its source is found a white sandstone of firm texture containing Scolithus borings. It has a dip of 45° S.E. which carries it across the head of Snow Creek to the crest of Piny Ridge which is not so elevated.

If we cross James River and follow the eastern face of the Blue Ridge toward the N.E. for several miles we find sandstones carrying Scolithus markings and beds of slate alternating with them, all dipping S.E. They correspond very closely in character and position with those described to the south of the river. Three miles N.E. of Rope Ferry a bed of these slates is quarried by the Virginia Slate Mining Co. for roofing purposes. They are somewhat different lithologically from the corresponding slates along the western slope of the Blue Ridge, being much more highly metamorphosed and hence having a more perfect cleavage.

The foregoing observations led to the conclusion that the stratified rocks upon the western and eastern slopes of the Blue Ridge belong to the same geological formation, and that the latter ought to be classed as Potsdam or Lower Cambrian instead of Archæan. This would make of the Blue Ridge an immense broken arch at Balcony Falls.

This broken arch or anticline is immediately succeeded by an unbroken syncline about two miles in width, near the axis of which is Rope Ferry Bridge. How far on either side of the river this syncline may extend we have not yet fully determined. The upper beds of sandstones and slates do not make their appearance for some distance on either side of the river, having probably been somewhat broken in their upheaval, and washed away before the river became confined to its present narrow channel.

It seems more than probable that ice was one of the great agents in determining the features of this region.

To the east of the syncline mentioned above we find Archæan rocks again represented by granite and gneiss. This corresponds to the axis of Cold Mt., which is a ridge lying several miles S.E. of the axis of the Blue Ridge and parallel with it. A few miles N.E. of this locality Cold Mt. is very high and conspicuous.

From what has been written above, the general conclusion may be drawn that the belt of sandstones and slates lying east of the Blue Ridge at Balcony Falls belongs to the Lower Cambrian or Potsdam group of rocks, and that the Primordial beach of the Palæozoic Sea was farther east at this locality than was formerly supposed.

Washington and Lee University, Lexington, Va.

ART. LXII.—*Geology of the Sea-bottom in the approaches to New York Bay;* by A. LINDENKOHL, U. S. Coast and Geodetic Survey. With a plate (Plate IV, unnumbered).

[Read at the meeting of the National Academy of Sciences, April 22, 1885, by J. E. HILGARD.]

DURING the survey of the sea-approaches to New York in the years 1842 and 1844, specimens of sea-bottom were collected while soundings were in progress. The samples were examined under the direction of Professor Bache by Assistant L. F. Pourtales of the Coast Survey Office and by Professor J. W. Bailey of West Point, N. Y., and the results of analyses were published as Appendix No. XI with the Coast Survey Report for the year 1869. The investigations by these naturalists attracted attention and ended in opening the way to a field of scientific inquiry which, at this time, is cultivated by men eminent in such researches in all the leading nations. Neither of the naturalists here named is now living.

Within the last five years, minute hydrographic surveys have been made of the same locality. Some collateral information also has been furnished by the Geological Survey of New Jersey under the direction of Professor George H. Cook. We are thus enabled to invest deductions with increased precision, and to extend inquiry beyond the limits to which Assistant Pourtales restricted himself.

The sea-bottom off the entrance to New York lower bay is characterized by features peculiar to that region. These include:

1. A well defined submarine valley.
2. An area of clay bottom extending about one hundred miles seaward.
3. A deep ravine at the edge of the continental slope.

The features here specified will be separately described.

Submarine Valley.—The early survey of the sea-approaches to New York developed the existence of a series of "deep mud holes" lying in a straight line off the entrance. These it was supposed might serve as guides to mariners, but no special significance was attached to the "mud holes" until Professor Dana, from a study of the Coast Survey soundings, showed that they lay in the course of a valley-like depression which had the right position to have been, in a period of higher level, the continuation of the Hudson River channel. When these views were communicated to the Coast Survey Office these mud holes were at once recognized as indications of such a channel, and it was surmised that they actually form a continuous channel instead of being separated. The last survey has developed the existence of this channel; and thus the question is opened—whether this channel was produced by a break in the strata as was the upper channel of the Hudson, or by the current of a river seeking an outlet to the ocean. The following facts bear upon the question.

The first indications of the channel are found ten nautical miles east by south off Sandy Hook at a depth of 19 fathoms. After following a southerly course for about ten miles, the channel takes an easterly turn in the next five miles; from the distance of fifteen miles (twenty miles in a direct line from the Hook) it maintains a straight course (60° S. E.) to its bar, which is eighty miles from the Hook.

From the head of the channel to the bend, the top of the banks remains at about an even level of 18 fathoms depth, while the channel increases in depth from 19 fathoms to 36 fathoms. The average slope of the banks is one degree, and the width of the enclosed channel from three quarters of a mile to a full mile; in the bend this slope is increased to three degrees, and the width contracted to one eighth of one mile.

The banks maintain the same height on both sides, and are, as also is the bottom, composed of a sandy clay overlaid by a crust of sand and gravel which spreads continuously over the adjacent flats. This clay is very uniformly described by the surveyors as "blue clay" in the upper channel and "green mud" in the lower channel. The bar (at seventy-five nautical miles from the Hook) is composed of fine sand. At the distance of eighty-five miles the channel reappears as a deep ravine and it will be described separately. The cross sections of the channel, at intervals of ten miles starting from Sandy Hook, taken from the recent survey, are here given:

Distance naut. miles.	Depth of channel below sea level in fathoms.	Distance from top of clay bank to sea level in fathoms.	Height of banks in fathoms.
10	25	17	8
20	35	20	15
30	37	22	15
40	42	27	15
50	41	30	11
60	43	36	7
70	43	38	5
(75)	(41)	(39)	2
80	43	43	0

From this exhibit we may infer that the channel has been produced by erosion and its present shape is due to the action of flowing water. The mud brought up by the lead has not been deposited upon the sea bottom by precipitation, but is the actual soil which is a stratum of clay which must have a thickness of over ninety feet.

This sandy clay is believed to be identical with the Tertiary "sandy clay strata" of the New Jersey geological survey which underlies nearly the whole of the peninsula of lower New Jersey.

The disappearance of the submerged valley at a less depth than 19 fathoms must be attributed to the obstructive action of Sandy Hook bar. By taking this depth as the greatest ever reached by the channel over the bar near Sandy Hook, we can form an estimate of the geological age of this bar.

Professor Cook, in a statement made before the Riparian Commission of New Jersey, November 17, 1883, estimates the present rate of subsidence of the coast of New Jersey at about two feet in a hundred years. At this rate, the decrease of depth from 19 fathoms to 4 fathoms which is about the present mean depth of the New York bar, would cover a period of four thousand five hundred years.

The transfer, per saltum, of a bar at the depth of 41 fathoms and at a distance of 75 miles from the Hook to one of 19 fathoms depth and in the immediate vicinity, however, cannot well be explained upon the theory of such a gradual and moderate subsidence as is believed to be going on at the present time.

The State Geologist, Professor Cook, assuming a mean dip of twenty-five feet to the mile for the marl beds, has indicated lines of strike upon his geological map, showing the depth below sea level of the red sand bed (a subordinate stratum of the Cretaceous marl formation) and the lines A and B on the map (see Plate) are such lines for the depths respectively of 250 feet and 1040 feet. These lines produced to the submerged channel strike the top of the clay bank at points the respective depths of which are 108 and 162 feet below the ocean level. This great difference in dip (790 feet against 54 feet) may be accounted for by supposing that the top of the clay bank does not coincide with the line of stratification (its slope being about two feet to the mile), or there may be a flattening out of dip toward the sea. And, again, the sandy clay bed may not rest conformably on the formations which crop out on the dry land.

In the geological surveys of Pennsylvania and New Jersey, the terminal moraine was accurately traced through these two States, and the sketch shows its course from the valley of the Alleghany in western New York, eastward and southward to New York Bay. The line as there shown was taken from a map by Professor Lewis in this Journal, 1884; and from the geological map of New Jersey, 1882. It will be seen at a glance that this line and the submerged valley of the Hudson form a continuous line, and this coincidence suggests that this valley stands as a mark of the limit of the glacial drift and as one of the "great waste-weirs of the melting glacier," to use an expression which Professor Lewis applies to the Lehigh river. The range of hills which traverses Long Island from the New York Narrows to Montauk Point has been recognized as a well developed glacial moraine, and Professor Cook has established its lateral connection with the New Jersey moraine by way of the southern part of Staten Island. Now if the contemporaneous existence of these two moraines could be proved, it would follow that the south end of Staten Island was the most advanced point of the glacier. Professor Chamberlin has very recently (in a contribution to the Annual Report of the U. S. Geol. Survey, 1882–83) made the relative ages of these two glaciers the subject of a careful study. For our present purpose it will suffice to state that the Long Island moraine, by reason of its great boldness, which implies a period of powerful glacial action, bears a greater resemblance to the more northerly moraines of the interior than to the terminal moraine which stands as the extreme advance of a gradually receding glacial drift. This circumstance alone warrants the assumption that the terminal moraine must be looked for to the southward of Long Island.

Clay Bottom.—Assistant Pourtales drew attention to a large area of muddy bottom off the eastern end of Long Island, and remarked also upon the scarcity of remains of animal life in the specimens of bottom from this region. That muddy bottom zone is interposed between the wide sand belt which skirts the coast and the deep sea ooze which is of calcareous nature and which covers all the deeper bottoms of the ocean. By careful study of the soundings, including those recorded by the U. S. Fish Commission, we are enabled to trace the outline of this formation. It is triangular; the base D E (see plate) coincides nearly with the line of 1000 fathoms and reaches from the latitude of Cape Charles to the longitude of Cape Sable. The apex (F) lies about ten miles southeast of Block Island, but a narrow strip of muddy bottom can be traced still farther north, nearly to the western end of Martha's Vineyard.

Assistant Pourtales says (C. S. Report for 1869, Appendix XI), "The mud or ooze had its origin probably in the Tertiary formation, of which we see only the remnants in the cliffs of Gay Head, and in a few localities of small extent on the coast of Massachusetts, as at Marshfield or elsewhere." . . . "A similar sea bottom is found in the so-called mud holes off the entrance to New York. They are depressions below the general depth of the surrounding bottom, filled with mud." These expressions do not render it clear to me whether he considered this mud to be sediment or true soil; but judging by the uniformity and the magnitude of its range, since the greater part if not the whole of the mud in question is either clay or corroded clay, we recognize in it the traces of a great geological formation having a vertical range of nearly six thousand feet. The sea-bottom within this area may contain the outcroppings of strata of various composition and of different ages, but these strata must be assumed to be always more or less argillaceous. The shoaler soundings generally show a strong admixture of sand while the deeper ones appear as purer clays. At about the depth of 1000 fathoms the clay gives way to the globigerina ooze; but in some instances clay has been found by the Fish Commission at depths over 1500 fathoms. In view of the fact that in coast regions the distribution of "sand" and "mud" bottoms is very often the result of ocean currents, it appears proper to define the extent to which such currents may have affected the limits of our "clay region."

We may freely admit that, in moderate depths, currents may disturb and shift the material of the bottom and may also change its mineral composition by the introduction of sediment washed out to sea, but such changes cannot take place at great depths nor at great distances from the coast and could have affected but a very limited part of the clay bottoms. The only agency which could change the geological structure of the sea bottom at the depth of the main part of the clay region, we take to be precipitation of very fine material held in suspension by the sea water; but the effect of such precipitation would be to obliterate existing geological distinctions rather than to render them more apparent.

A line drawn from Trenton to Jersey City separates the clay region from the red sandstone region. This line is about one hundred and fifty miles from the curve of one thousand fathoms. Hence, if we assume these two lines to be on one plane of stratification, the dip of the strata would be forty feet to the mile. It appears quite plausible to assume that the dip of pliable strata which is found to be decreasing in the coast region should show an accelerated increase when it approaches the continental slope.

It has been suggested by Professor Dana and is so stated in Dana's "Manual of Geology," 2d edition, p. 537, that the lower limit of the New England part of the terminal moraine probably coincided with the outline of the deep water slope, about 80 miles south of Long Island and outside of St. George's Shoal. Now, the clay bottom region being bare of drift, we can safely assume that the lines F D and F E indicate the extreme limit of glacial drift on this part of the continent. The thickness of the cover of diluvial drift in the vicinity of the submerged valley appears to be at the utmost about sixty feet.

The Hudson River Fiord.—The deep ravine mentioned above as one of the remarkable features of the sea-approaches to

New York lies in a nearly straight continuation of the submarine channel and reaches from the outer end of the bar already mentioned, or about eighty-five miles to seaward from Sandy Hook, to the edge of the continental slope at a distance of about one hundred and five miles from the Hook. This ravine is about twenty-five nautical miles long and three miles wide. It commences with a depth of about sixty fathoms below the ocean's surface which increases to two hundred fathoms within the first mile; the greatest depth, four hundred and seventy-four fathoms, is close to its outlet. This outlet to the ocean is in the shape of a bar with a depth of about two hundred fathoms. For half its length, from its middle to the bar, this ravine maintains a vertical depth of more than two thousand feet, measuring from the top of its banks; these banks have a nearly uniform slope of about 14°. It remains to be stated that the bottom and the sides of the ravine are composed of a green sandy mud, and that the adjacent flats, unlike those of the submerged channel, show the same material.

The absence of signs of violent action in the region of this depression precludes the supposition that it is a fissure; on the contrary its position at the lower limit of the glacier, its shape, and its direction, render probable the supposition that it belongs to the class of fiords so common to higher latitudes. If we so conclude, the question cannot be avoided—why is the continuity of the submerged channel interrupted by a bar. The borings at Cape May, at Atlantic City and elsewhere along the New Jersey sea border carried down to depths of two hundred feet or more, do not show any harder strata than clay. Hence there is no reason to assume that this bar was induced by a rocky obstruction. It appears more plausible to suppose that the fiord belongs to an earlier time when the river made its channel to the sea through ice obstructions, and that the submerged channel farther up is of a later period, when the passage to the ocean was free and the régime of the river was well established.

ART. LXIII. — *Additional Notes on the Kettle-Holes of the Wood's Holl Region, Massachusetts;* by B. F. KOONS.

DURING the summer of 1884, in connection with my work for the United States Fish Commission at Wood's Holl, I extended my observations, as far as opportunity offered, on the kettle-holes in the Vineyard Sound region, partly to revisit localities studied the year before (and complete work then left unfinished), and in part to give wider range to recorded facts.

Soon after my former article appeared in the Journal of Science, April, 1884, numerous inquiries were made by various geologists of the United States, showing a much wider interest in the subject than had been anticipated, and some of these questions bore upon points not particularly studied, while others asked for further explanation of facts there recorded. A part of these questions have been answered by letter, and in the following notes I shall aim to reply to the remainder either directly or indirectly. The previous article gave my observations made upon the east end of Naushon, the point of the main land, and the intervening islands, about twelve miles in extent, and sixty-four kettle-holes were located and described; and in the later observations a territory extending from Robinson's Holl on the west to a point several miles north of Falmouth village, over twenty miles in all, was visited, and I here give the measurements for forty-two additional.

On the Island of Naushon.

No.	Direction of long axis.	Length of long axis.	Length of short axis.	Height of highest border.	Height of outlet.	Position of outlet.
65	N. 50° E.	20 rods.	7 rods.	25 ft.	8 ft.	S.W.
66	N. 55°–60° E.	25	15	30	15	S.
67	N. 50°–55° E.	20	16	30	10	S.W. by W.
68	N. 55° E.	20	12	25	12	N.W. by W.
69	N. 40° W.	20	8	73	31	S.E.
70	N. 25° E.	10	8	30	22	S.W.
71	N. 50° E.	8	5	35	8	N.E. by N.
72	N. 80° E.	25	10	45	30	S.W.
73	N. 15° E.	18	7	30	12	N.E.
74	N. 50° E.	18	7	70	30	N.E.
75	N. 70° E.	7	5	65	20	S.E. by S.
76	N. 50° E.	25	8	48	20	E. by S.
77	N. 60° E.	12	10	40	12	N.
78	N. 60° E.	25	18	60	20	W.S.W.
79	N. ———	20	20	30	20	S.
80	N. 80° E.	18	7	48	18	S. by W
81	N. 80° E.	18	8	49	20	S.
82	N. 80° E.	45	10	65	25	N. by W.
83	N. 90° E.	7	4	18	10	N.N.E.
84	N. 70° E.	45	16	60	25	N.E. by N.

On the mainland east of Wood's Holl.

85	N. 35° E.	16	6	35	13	S.W. by S.
86	N. 20° E.	45	8	60	12	N.E. by N.
87	N. ———	25	9	45	25	N. by W.
88	N. 5° W.	10	6	38	16	S. by E.
89	N. 50° E.	34	10	40	20	S. by W.
90	N 45° E.	20	12	25	10	E. by N.
91	N. 20° E.	30	20	80	35	S.S.W.
92	N. 90° E.	40	10	90	30	S.E. by E.
93	N. 80° E.	8	4	75	8	S.E. by S.
94	N. 40° E.	32	7	70	35	S. by E.
95	N. 60° E.	50	30	40	10	W.
96	N. 40° E.	18	10	90	25	N.W.

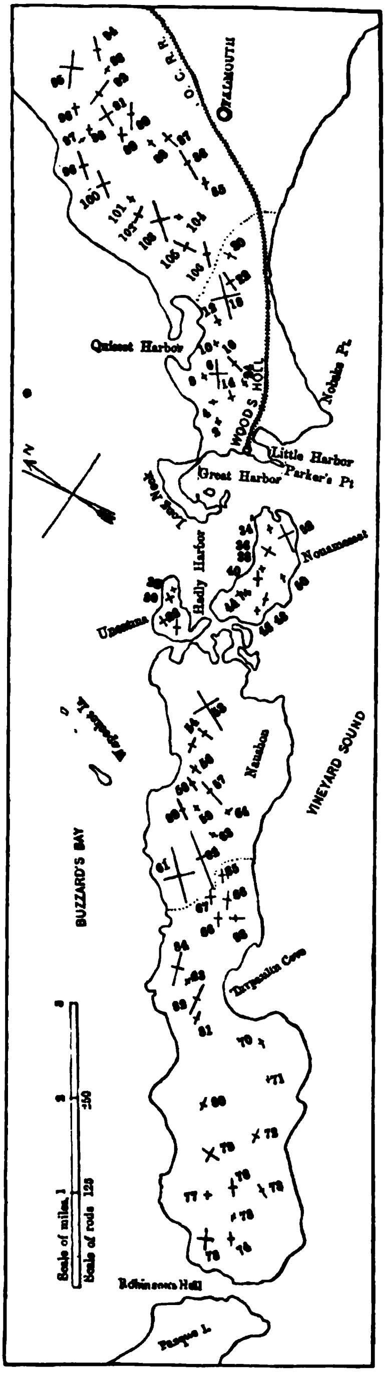
On the mainland east of Wood's Holl—continued.

97	N. 80° W.	8	4	60	12	E. by N.
98	N. 45° E.	12	5	60	12	N.E. by W.
99	N. 30° E.	40	12	100	50	N.E.
100	N. 45° W.	40	20	80	30	N.E.
101	N. 10° W.	8	4	30	12	N. by W.
102	N. 80° E.	23	8	40	15	N.E. by E.
103	N. 35° E.	55	28	75	45	E. by N.
104	N. 35° W.	10	6	25	12	S.E. by S.
105	N. 10° W.	30	9	70	20	
106	N. 45° E.	35	7	50	10	

However, these represent certainly less than one-tenth, possibly less than one-fifteenth of all that are to be found within the region examined. Upon further examination I find that while there are large numbers upon the south slope of the moraine, and some too of very large dimensions, yet by far the greatest number and the largest are upon the side from which the glacier came, and this is what we should expect if the kettle-holes mark the localities where fragments of ice were broken off from the face of the glacier and buried, wholly or in part, by the earth and stones borne down by the ice-sheet. Also the direction of the longer axis is just what we should most naturally expect in kettle-holes made by such ice-masses. Certainly they are not uniformly parallel to the face of the glacier, nor would we expect them to be so; yet an examination of the map and tables accompanying this and the former article will show that their general direction approximates to this.

One inquirer asks, "Are the basins on the crest of the moraine more frequently transverse to, and those on the inner slope more apt to be parallel with, the moraine or following the configuration of the country toward outlets or gaps through the moraine?"

Upon a careful examination of the facts, both in the field and those of formerly recorded measurements, I fail to discover any such law. The question was asked in the light of the possibility of the kettle-holes being made by streams of water pouring from the face of the glacier and eroding along the lines of freest discharge, somewhat after the manner of streams of the present, gouging out deep holes along their beds which are connected by very shallow rills at low water: or, as often occurs in western streams in dry seasons, leaving deep holes as small ponds or pools with no water flowing from one to the other. No such arrangement can be made out among the kettle-holes of this region for they are distributed singly and in groups without any connection or arrangement indicating that they were made by torrents of flowing waters. At one point on the south side of Naushon, in an open space near Tarpaulin Cove, there are twelve or fifteen of medium size, very closely packed together, and so completely without arrangement



that they seem to have no relation whatever one to another; and many other localities are quite as remarkable for the great number and size of their kettle-holes. Often when two of these depressions are near each other the highest border of each is between them and their outlets in opposite directions. And again it is often found that the slope of the outlet is even as high as 30°, which would preclude the idea of flowing waters making them; for it would be very difficult to secure such a flow of waters as would scoop out a cavity on so gigantic a scale as some of these kettle-holes and carry the material up an inclined plane several rods in length at an angle of over 30°, possibly 40°, for some of them were of the steeper angle when made. And further, if they had been scooped out by water, and the mud and fine material carried away they would have been left at least partly filled with bowlders, but the bottoms and largely the sides are quite free from them. Those found at the bottom of the depressions have probably been exposed by erosion and then rolled down from some of the surrounding slopes, for the washing of material from the sides into the pits during the ages since the Glacial period would be sufficient to expose the bowlders as we find them now.

Nor does an examination of the general arrangement of the outlets to the kettle-holes (by the outlet I mean the lowest point in the rim), indicate that flowing water made them, for often if they were made in this way the water must have found its way directly back into the face of the glacier if the lowest point is any indication as to the direction of the flow.

We find kettle-holes also below sea-level. There is one in Great Harbor, at Wood's Holl, nineteen fathoms deep with shallow water all around; and it is said that it has been gradually filling within the memory of men. One in Vineyard Sound is forty fathoms deep with the water only ten on its borders. Professor Verrill also informs me of another off Cape Ann ninety fathoms deep while the water about is from thirty to forty.

Upon conversing with the various naturalists of our United States Fish Commission corps who are familiar with the geological features about Vineyard Sound, and more especially Professors Baird and Verrill, they express themselves very decidedly of the opinion that flowing water could not be the agency that made them. "The structure, arrangement, and all their features utterly preclude the idea." Also Professor Linton, who has accompanied me each year in a part of my studies, is of the same opinion.

There is one place between Wood's Holl and Falmouth, however, where it is very evident that a stream did flow to the south from among the hills, and the bed and sides of this are very different from the ordinary slopes and bottom of the kettle-holes. The former are almost paved with bowlders just as we should expect to find them in the bed of a stream flowing through such material as the glacial drift, while, as stated above, the kettle-holes are quite free from them.

There are also evidences two miles west of Tarpaulin Cove, on the south side of Naushon, that a glacial stream, of no mean proportion, swept from among the hills in the center of the island into Vineyard Sound. The exact windings of the stream are easily traced, and just to the west of its mouth stratified deposits are found cropping out in the bluff seventy-five feet above mean tide; but this river channel, unlike the one found on the mainland east of Wood's Holl, has few bowlders in it because of the fineness of the material composing the west end of the island, and the notable absence usually of large rock fragments especially at this point.

Stratified deposits composed of clay and sand more or less fine are found in various other localities. Beyond Quisset Harbor nearly to the extreme northeast point visited, a finely laminated clay bed several feet in thickness and covering considerable area is found with no coarse material over it but large bowlders near by. At several points on the road between Wood's Holl and Falmouth thin beds of stratified material are found, one of which dips at an angle of about thirty degrees; but most likely this is due to local displacement, perhaps a sliding of a bank rather than a general disturbance of the surface of the region. These stratified deposits are found in a great many localities, both upon the mainland and the islands, and often upon the highest points of the region; the most extensive of all (described in my former article) are upon the very summit of Naushon over two hundred feet above the sea. At times they are overlaid by coarse unmodified drift, at others occupy the surface; and upon a study of the localities and the character of the deposits it seems that they were made by the flowing waters of the streams as they ran from the face of the glacier and found their way over the terminal moraine into the sea beyond.

Doubtless the borders of the kettle-holes were much higher at the close of the Glacial period, and the depressions themselves much deeper; and perhaps we can safely add one-third or one-half to the measurements; and, as mentioned elsewhere, the angle of the slope has been much reduced; however, no excavation or railroad cut has yet afforded an opportunity for the examination of the formations at the bottom of these depressions.

It will be noticed that just east of Quisset Harbor the general direction of the long axes changes, and instead of having the same trend with those on the Elizabeth Islands and the point of the peninsula near the village of Wood's Holl, it swings around toward the north to about N. 25° or 30° E.; and just here Mr. Warren Upham made an angle in the terminal moraine.*

Clarence King, Mr. Upham and others make the Elizabeth Islands and the line of hills about Wood's Holl, Falmouth, Quisset, etc., a portion of an inner moraine, and Martha's Vineyard, Nantucket, etc., marking the outer. I have not been able to devote any time to the study of the outer moraine upon the islands except to note a few features of No Man's Land. It has been asserted, but certainly by those who have not examined the island carefully, that the south shore is in large part made up of ledges, but a visit failed to discover them. However clear evidences of large beds of stratified material, doubtless of the so-called Tertiary, similar to some of those at Gay Head at the west end of Martha's Vineyard, extend along the south shore in a cliff seventy-five feet high, with a layer about five feet thick of very coarse unstratified material upon the top. These stratified beds have a strike of N. 50° W., dip 25° N.E. There are also stratified deposits cropping out along the east side of the island, and the encroachments of the sea upon that part of the shore show the edge of a considerable deposit of peat in a depression some forty feet above the sea. We were informed by one well acquainted with the island that a pole thrust down into it shows the bed to be twenty feet thick.

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* This Journal, III, vol. xviii, p. 203.

Remote from the sea, upon Naushon and the other islands, there are found large numbers of shells of both lamellibranch and gasteropod mollusks, often unbroken, and even the valves of the lamellibranchs not separated, the carapaces and at times whole crabs, shells of barnacles, etc., which are carried there by the birds, more particularly by the crow, as it is found that they depend largely upon these animals for their food. Doubtless these animal remains are buried and preserved by the drifting sands, and this fact possibly should modify the views of those who would draw very sharp lines, upon the ground of fossils alone, between marine sedimentary and other deposits. Also ripple-marks made by the winds, and as perfect as are ever formed by the waters, were found covering considerable areas in the sands high above the sea.

ART. LXIV.—*Cause of the apparently perfect cleavage in American Sphene* (*Titanite*); by GEO. H. WILLIAMS.

MANY minerals, like diallage, bronzite, sanidine, etc., are known to possess a "parting" (German *Absonderung*) in certain directions which is essentially different from a true cleavage. This may be due to interrupted growth of the crystal, to regularly arranged inclusions or to other causes not always easy to explain. Professor G. vom Rath of Bonn has recently demonstrated that the very perfect parting, which exists in some varieties of pyroxene parallel to the basal pinacoid, is produced by the interposition of exceedingly thin twinning lamellæ.* These are so very narrow ($\frac{1}{8}$–$\frac{1}{4}^{\mathrm{mm}}$) that they were for a long time entirely overlooked. This structure is especially characteristic of the salite occurring so abundantly in northern New York and Canada, and seems always to be due to the same twinning lamellæ which vom Rath first observed in crystals of diopside from Achmatowsk in the Urals.

In hornblende such a parting parallel to the basal plane is very exceptional, although it is has been observed by the writer in certain dark brown crystals from South Pierrepont, St. Lawrence Co., N. Y. It is here also due to the presence of twinning lamellæ as in the case of salite. The same parting produced by twinning lamellæ inserted parallel to the faces of the fundamental rhombohedron is well known in corundum and hematite crystals from many localities.

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* Zeitschrift für Krystallographie, v, p. 495. 1881.

During his recent visit to this country, Professor vom Rath suggested to the writer that the apparently perfect cleavage so often observed in the American sphene might be due to precisely the same cause, and such indeed upon investigation turns out to be the fact.

The cleavage of sphene is variously given by different authors, and seems not to be at all constant in specimens from different localities. As early as 1840, Professor C. U. Shepard figured and described crystals from Natural Bridge, Lewis Co., N. Y., and from Grenville in Canada, upon which two apparently perfect cleavages were observed meeting at an angle of 123° 30′, or as afterward more accurately determined by Brooke, 125° 30′. The somewhat abnormal habit of these crystals together with this cleavage seemed to Professor Shepard a sufficient ground for designating them as a new species, which he did under the name of *lederite*.[*] In speaking of the "Gelbmenakerz" of Werner, a massive variety of sphene from Arendal in Norway, Professor Quenstedt says: "Ihr Aussehen erinnert an Spatheisenstein, allein wir haben nur zwei blättrige Brüche, die sich etwa unter 125° schneiden, aber mehr schaligen Absonderungen gleichen."[†] The same cleavage angle (125½°) is also given by Blomstrand as occurring in the variety of sphene from Småland, Sweden, recently named by him alshedite.[‡]

The sphene which occurs so abundantly in this country associated with various silicates or with apatite in the limestones of the Laurentian, is almost always of a chocolate-brown color, and shows when in distinct crystals the habit of the variety called by Shepard lederite, (see figure). Whenever anything resembling a cleavage is present, the surfaces meet under the angle given above, corresponding to that of the pyramid $-4P$ (according to Dana). This is, however, not a true cleavage but a parting caused by repeated twinning, as in the case of salite.

That the exact position of these lamellæ may be better understood, a figure of a crystal of the lederite type is here given with the following table of the different symbols assigned to the planes by G. Rose,[§] Des Cloizeaux,[‖] and Professor J. D. Dana.[¶]

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[*] This Journal, I, xxxix, p. 357. 1840.

[†] Handbuch der Mineralogie, 3d ed., p. 440. 1877.

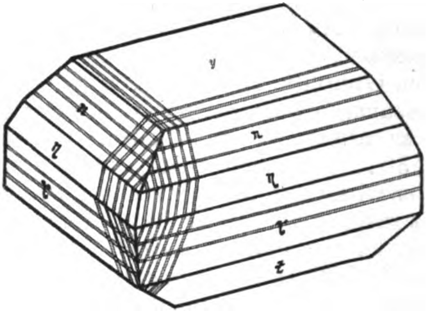
[‡] Dana, Syst. Min., III Appendix, p. 122.

[§] De Sphenis, etc. Inaug. Disser., Berlin, 1820.

[‖] Manuel de Min., i, p. 146. 1862.

[¶] Syst. Min., 5th ed., p. 384. (The signs of the hemipyramids are changed to accord with general usage.)

Rose.		*Des Cloizeaux.*		*Dana.*	
$P\infty$	(y)	$0P$	(p)	$0P$	(O)
$\frac{2}{3}P\grave{2}$	(n)	$-P$	($d^{\frac{1}{2}}$)	$-2P$	(2)
$\frac{4}{5}P\grave{4}$	(η)	$-2P$	($d^{\frac{1}{4}}$)	$-4P$	(4)
$P\grave{\infty}$	(r)	∞P	(m)	∞P	(I)
$-2\grave{P}2$	(t)	P	($b^{\frac{1}{2}}$)	$2P$	(-2)



The face η is not common. It has been observed by Des Cloizeaux on greenovite, the manganese sphene from St. Marcel, Piedmont,* and by Hessenberg on crystals from Pfitsch in Switzerland.† It is also present on several crystals of the lederite habit in my possession, occurring with apatite in a red calcite near Eganville, Renfrew Co., Canada. This face lies in the zone $y:r$ and makes with y an angle of 130° 27′—(calculated 130° 45′ (Des Cl.)). In one of the crystals showing this plane the parting is exceptionally well developed; and the simultaneous reflections from both the crystal plane and parting surface shows that they are exactly parallel.

The most perfect development of this parting which I have anywhere observed is in the silvery-brown sphene, associated with the white microcline and green malacolite from Pitcairn, St. Lawrence Co., N. Y. These minerals are found imbedded in a coarse grained calcite and all have their faces and angles so rounded that accurate crystallographic determinations are very difficult. The malacolite shows a perfect parting parallel to $0P$. In the sphene the parting is, as a rule, much more perfectly developed parallel to one pyramid face than it is parallel to the other. After a number of trials such pieces were obtained as gave equally distinct reflections from both surfaces and the angle between them was determined by measurement to be 125° 26′. The calculated angle, as given by Des

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* Manuel de Min., i, pl. xli, fig. 245. 1862.

† Mineral. Notizen, No. 4, p. 18, figs. 14, 15, 18, 19. 1861.

Cloizeaux,[*] between $\eta \wedge \eta$ is 125° 42′, so that the agreement is as great as could be expected in consideration of the reflections never being perfectly sharp.

The frequent total absence of this parting in one portion of a crystal when it is highly developed in another part, as well as the fact that it is to be found parallel to only one of the two pyramidal faces, shows that it is not to be regarded as a true cleavage.

It is furthermore easy to convince oneself by a careful inspection of such crystals as show it most perfectly, that this parting is really due to repeated twinning. The interposed lamellæ are so narrow as to be readily overlooked. They run around the crystal in the direction indicated in the figure—though of course in much greater numbers—meeting the edge $r \wedge r$ at an angle of about 16°. On the crystals from Pitcairn especially, the lamellæ are sometimes broad enough to give bright reflections of their own, and in one case it was possible to measure the inclination of the face *r* to the lamellæ traversing it as 159° 17′. The truly hemitropic character of these lamellæ is best shown in polarized light. A section of a Pitcairn crystal cut parallel to one of the parting surfaces showed parallel bands, similar to those observed in calcite, when this mineral is twinned according to $-\frac{1}{2}R$. The width of these bands varies from $\frac{1}{8}$ to $\frac{1}{30}$ of a millimeter, each one frequently appearing to be made up of innumerable narrower ones. They often change in width and sometimes either pinch out gradually or suddenly disappear. No accurate measurements of the angle of extinction of these bands could be made on account of the very high refractive index of the mineral.

There seems, therefore, to be little doubt that the apparently perfect cleavage, so characteristic of much of the American sphene is produced by a polysynthetic twinning parallel to the face η ($= -4P$ Dana, $-2P$ Des Cloizeaux, $\frac{4}{3}P\grave{4}$ Rose), a fact that is of interest as well for being a new twinning law for this mineral as an explanation of its characteristic parting.

In light of the recent investigations by Mügge,[†] Förstner[‡] and others, on the production of secondary twinning lamellæ by pressure, it seems not improbable that the above described structure in sphene may be also due to the same cause. This seems the more likely since all the other minerals associated with the sphene from Pitcairn, in which the parting is most perfectly developed, show in a greater or less degree effects of the same kind. The calcite in which all the minerals are imbedded always has polysynthetic lamellæ parallel $-\frac{1}{2}R$, the green malacolite has a very perfect parting due to twinning lamellæ parallel $0P$, while even the white feldspar crystals (microcline) possess in the greatest perfection that peculiar microperthitic interlamination of albite substance which Lehmann has also ascribed to the action of powerful pressure.*

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[*] Manuel de Min., i, p. 148, 1862.

[†] Neues Jahrbuch für Min., etc., 1883, i, p. 32; ib., ii, p. 13; ib., 1884, i, p. 216.

[‡] Zeitschrift für Krystallographie, vol. ix, 351, 1884.

Petrographical Laboratory, Johns Hopkins University, March 26, 1885.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Report on the results of an investigation as to the chemical methods in use for the determination of organic matter in potable water;* by Professor J. W. Mallet, F.R.S., University of Virginia (forming appendix D to the Annual Report of the National Board of Health for 1882, pp. 189–353, with 48 tables and several wood-cut figures).—A preliminary report on the general results of this investigation was published by the National Board of Health some three years ago, but the full report has but recently appeared, giving all details as to the kinds of water examined, the analytical methods investigated, the tests to which these were subjected, the results obtained, and the conclusions reached from these results.

The specimens of water examined — 161 in number — were grouped under the following heads:

Class I.—Natural waters, believed from actual use to be of good, wholesome character, including the regular water supply of some of the principal cities of the United States.

Class II.—Natural waters which there seems to be fair ground for believing have actually caused disease on the part of those drinking them. A request for information as to such waters, and for samples of them, was published for several months in the National Board of Health Bulletin, and was extensively copied into newspapers and professional journals, and a copious correspondence with physicians and others in various parts of the country was employed to secure such samples and to sift the evidence as to the supposed connection of each water with the production of disease.

Class III.—Natural waters of doubtful but more or less suspected character. In reference to these the medical evidence was insufficient to justify placing them in class II.

Class IV.—Artificially prepared waters, made by adding to good, wholesome water, determinate amounts of various infusions of *vegetable* organic matter, of natural origin, and of such kinds chiefly as water for human consumption is liable to come in contact with.

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* Untersuchungen über die Entstehung der altkrystallinischen Schiefergesteine. Bonn, 1884, p. 217.

Class V.—Artificially prepared waters, made as above, with various forms of *vegetable* refuse from manufacturing or industrial operations.

Class VI.—Artificially prepared waters, as above, made with *animal* (or partly animal) organic matters of natural origin, especially such as are likely to occur in connection with the contamination of drinking water.

Class VII.—Artificially prepared waters, as above, made with *animal* refuse from manufacturing or industrial operations.

Class VIII.—Artificially prepared waters, as above, to which had been added morbid products from certain diseases in the human subject.

Class IX.—Solutions, in distilled water, of carefully determined amounts of pure organic substances of definite chemical composition.

The three methods, with various modifications of the same, for the determination of organic matter which were investigated were:

(1) The "combustion process" of Frankland and Armstrong; (2) The "albuminoid-ammonia process" of Wanklyn, Chapman and Smith; and (3) The "permanganate process," originally suggested by Forchhammer, in the forms advocated by Tidy and Kubel respectively.

The specimens of water, supplied under precisely similar conditions, were simultaneously examined by these methods in the hands of three independent analysts, well trained for the work, one in Baltimore, one in Washington, and one at the University of Virginia—all quite ignorant of the history and character of the specimens submitted to them, these specimens being designated solely by an arbitrary series of numbers.

At the same time a microscopic examination of each water was made and a pathological investigation of its effect (when concentrated by evaporation at very low temperature) upon rabbits by hypodermic injection, under the direction of Professor H. Newell Martin, of the Johns Hopkins University.

A detailed criticism of each of the methods examined is given, noticing the special advantages and defects of each, with suggestions for the practical modification of these methods with a view to their improvement.

The chief interest of this report in its complete form consists in the study by comparison with each other of the results given in the series of tables, illustrating pretty fully the bearing of the different conditions involved—character of water examined, state in which its organic matter was present when examined, precise conditions of application of the methods used, different character of the results deducible from each of these, etc.

The most important general conclusions arrived at as to the value for sanitary purposes of the different processes studied are the following:

(1.) It is not possible to decide absolutely upon the wholesomeness or unwholesomeness of a drinking water by the mere use of any of the processes examined for the estimation of organic matter or its constituents.

(2.) In judging the sanitary character of a water not only must such processes be used in connection with the investigation of other evidence of a more general sort, as to the source and history of the water, but should even be deemed of but secondary importance in weighing the reasons for accepting or rejecting a water not manifestly unfit for drinking on other grounds.

(3.) There are no sound grounds on which to establish such general "standards of purity" as have been proposed looking to exact amounts of organic carbon or nitrogen, "albuminoid-ammonia," oxygen of permanganate consumed, etc., as permissible or not. Distinctions drawn by the application of such standards are arbitrary and may be misleading.

(4.) Two entirely legitimate directions seem to be open for the useful examination by chemical means of the organic constituents of drinking water, namely: first, the detection of *very gross* pollution, such as the contamination of the water of a well by accidental bursting or crushing of soil-pipes, leakage of drains, etc.; and secondly, the periodical examination of a water supply, as of a great city, in order that, the normal or usual character of the water having been previously ascertained, any suspicious changes which from time to time may occur, shall be promptly detected and their cause investigated.

(5.) In connection with this latter application of water analysis there seems to be no objection to the establishment of *local* "standards of purity" for drinking water, based on sufficiently thorough examination of the water supply in its usual condition.

(6.) The facts of this investigation tend to show that special and very great importance should be attached to a careful determination of the nitrites and nitrates in water to be used for drinking. No aspect in which the good and bad natural waters have been compared has afforded so definite a result as this.

(7.) In watching a large city water supply use should be made of all three of the principal processes for the examination of the organic matter present; each gives a certain kind of information which the others do not afford. Under circumstances admitting only of the use of simple means of investigation, the albuminoid-ammonia and permanganate processes might be employed together, but in no case should one only of these methods be resorted to, such a course entailing practically the neglect of carbon on the one hand or nitrogen on the other.

Among the more interesting special conclusions reached may be quoted the following:

(1.) Distinct proof has been obtained that in the "combustion process" there are two constantly present errors, varying but usually important in amount, namely: loss of carbon during the evaporation of the water, and gain of nitrogen from ammonia in the atmosphere surrounding the gas flame, the latter probably partly balanced by loss of nitrogen originally present in the water.

(2.) It has been shown that within a practically reasonable time enough water for the application of the combustion process may be evaporated in a closed vessel and under greatly reduced pressure at a temperature but little over 30° C., and that decidedly improved results may be obtained by thus modifying the process.

(3.) In regard to the Wanklyn "ammonia process" it has been ascertained that in the determination both of "free" and "albuminoid" ammonia there is a loss, sometimes quite considerable in amount, resulting from imperfect condensation of the ammonia during distillation.

(4.) In the application of the same process it has been proved that in some cases nitrogenous organic matter is volatilized during the distillation for "free" ammonia, and the amount of so-called "albuminoid" ammonia thus made to appear less than it should be.

(5.) As regards the "permanganate process" it seems that the amount of oxygen consumed by a specimen of water is probably in all ordinary cases much below that required for complete oxidation of the organic matter present, and does not stand in any fixed ratio thereto. It cannot be taken as a measure either of the organic carbon or of the total organic matter, though a distinct general resemblance can be traced between strongly marked results, high or low, as the case may be, for the consumption of oxygen on the one hand and organic carbon (by the combustion process) on the other.

(6.) The conclusions commonly drawn from the ratio of carbon to nitrogen in the organic matter of water as to this organic matter being of *vegetable* or *animal* origin may in some cases be quite erroneous. Thus, for instance, this ratio would in the case of water contaminated by the alkaline washings from the manufacture of starch, lead to the belief that animal matter was present, while in water to which an infusion of human fæces had been added the ratio in question would indicate vegetable impurity.

(7.) The biological experiments (on rabbits) serve to show that the general belief in the greater danger arising from the presence of animal rather than vegetable organic matter in water is not to be accepted without qualification or exception. Most strongly marked pathological effects were produced (and verified by repetition) by water to which there had simply been added an infusion of dead forest leaves, such as is washed away in immense quantity in autumn and winter from the surface of any woodland country.

(8.) The very small absolute amount of organic matter indicated as present in many of the most dangerous waters examined furnishes evidence against any purely chemical theory of the production of disease from this source, and tends to support the belief that not to the direct effect of any chemical substances (such effect necessarily standing in definite relation to their quantity), but to the presence of living organisms with their power of practically unlimited self-multiplication, we must in all probability look for an explanation of most at any rate of the mischief attributable to drinking water. At the same time it is of course possible that indirectly a large amount of organic matter in water may be more dangerous than a smaller quantity, as furnishing on a greater scale the suitable material and conditions for the development of noxious as well as harmless organisms.

(9.) The biological experiments indicated by some of their results, not only the probability that the pernicious character of certain waters was referable to the presence and action of living organisms, but also the possibility that a water containing organic matter of any kind may be harmless at one time and harmful at another, when perhaps a different stage of fermentative or putrefactive change may have been entered upon, and special organisms may have made their appearance or entered upon a new phase of existence.

The Report is marred by some typographical errors arising from its being printed without the proof-sheets having been submitted to the author for correction. The most important mistake in the printing consists in the "general discussion of results" being given first as a reproduction of the preliminary report, instead of appearing in proper place at the end of the main report; all the matter from the lower part of p. 190 to p. 211 inclusive, should be transferred so as to come immediately before p. 307.

Those who may desire to see the Report itself should apply to W. P. Dunwoody, Esq., Secretary of the National Board of Health, Washington, D. C.

2. *Radiation from incandescent lamps.*—Crookes, from the result of experiments on the radiation from thermometer-bulbs in high vacua, has concluded that at pressures between forty millionths and one millionth of an atmosphere the radiation varies as the mean molecular free path. Captain Abney lately communicated to the Physical Society of London the results of experiments upon the radiation from incandescent electric lamps contained in thin glass bulbs. It was found that from forty millionths to ten millionths of an atmosphere the radiation increases uniformly with decrease of pressure, but beyond this point it becomes nearly constant. The amount of radiation for any ray of the spectrum was then determined by means of a thermopile, and the result was then plotted, with watts as abscissæ and radiation as ordinates. The curves for each kind of ray were found to be hyperbolas with vertical axes. The result gave a method for rendering identical the quality of the light emitted by any two lamps. The radiation is found for any particular ray, and by examining the curve corresponding to that ray from the other lamp one can find for what number of watts the radiation is the same.—*Nature*, April 2, 1885, p. 523. J. T.

3. *Measurement of low temperatures.* — M. **Wroblewski** has compared the indications of a hydrogen thermometer and a thermal junction. The hydrogen thermometer indicates, below —193° C., temperatures lower than the thermal junction, which shows that hydrogen below the above temperature contracts more than the laws of Mariotte and Gay-Lussac demand. This departure increases with the depth of temperature. Thus the hydrogen thermometer gives for the temperature of solidification of oxide of carbon and azote —207° C. and —214° C. The thermal junction gave —199° C. and —203° C. The regularity of the thermo-electric curve shows that the thermal junction gives more reliable indications than the air thermometer at very low temperatures. When oxygen, azote, and oxide of carbon are evaporated in a vacuum the temperature falls only a few degrees below —200° C. The author also maintains that the law of liquefaction of atmospheric air is not that of a simple gas; but acts like a mixture of which the components have different laws of liquefaction.—*Comptes Rendus*, April 13, 1885, p. 979. J. T.

4. *New property of Selenium.*—**Werner Siemens** has examined the new selenium cells made by Mr. Fritts, of New York, and states that they possess great sensitiveness to rays of light of certain refrangibility. These cells consist of a thin homogeneous layer of selenium spread on a metal plate. This layer is heated to convert it from amorphous to crystalline selenium, and is then coated with fine gold leaf. One of the plates examined by Siemens was not sensitive to light; when, however, a galvanometer was intercalated between the gold leaf and the base plate, the existence of an electrical current was detected. The difference of potential was apparently proportional to the light, and it remained during the illumination. The infra-red rays did not produce this difference of potential. This electromotive force increased from 9.30 A. M. to 11.35 A. M.; remained constant for some time, and then decreased to 3 P. M.—*Sitzungsberichte der Akad. der Wissen. zu Berlin*, Feb. 12, 1885. J. T.

5. *On the depth in the sea to which light penetrates.*—MM. H. **Lol** and **Ed. Sarasin**, who have studied the absorption of light by the water of Lake Geneva, have extended their researches to the water of the Mediterranean. The photographic plates, which were lowered to different depths, were protected from the action of salt water by a bituminous varnish, which was removed by spirits of turpentine and alcohol before the plates were developed. The authors conclude from their experiments that during the month of March, at midday and under a clear sky, the diurnal rays are arrested at a depth of 400^{m}.—*Comptes Rendus*, April 13, 1885, pp. 991–994. J. T.

6. *Thermo-electric piles.*—The Clamond battery is constructed of couples of iron or nickel and an alloy of antimony and zinc. M. Clamond and M. Carpenter have lately greatly increased the efficiency of this battery. One model consisting of 120 elements gave 8 volts and had an internal resistance of 3·2 ohms; another

of 60 elements gave 3·6 volts with an internal resistance of 0·65 ohms. The amount of gas consumed by both models was 180 liters per hour.

II. GEOLOGY AND MINERALOGY.

1. *International Geological Congress.*—The third session of the International Geological Congress will be opened at Berlin on the 28th of September, under the honorary presidency of Dr. H. von Dechen, and will continue to October 3d. Geological excursions will occupy from the 5th to the 10th of October. Those intending to be present should announce it soon to the secretary of the Committee of Organization, Berlin, No. 44 Invalidenstrasse, with a mention of residence and position. The fee for new members, 12 francs, may be sent with the letter announcing the proposed attendance.

2. *Pennsylvania Geological Atlas of Counties.* — Professor Lesley, the Director of the Geological Survey of Pennsylvania, has published, in *octavo* form, an atlas of County geological maps, sixty-seven in number and admirable in all respects, together with introductory text containing a general account of the several counties both topographical and geological. It is exceedingly gratifying to have such an example of geological maps on a convenient scale for use, and maps that contain, in most cases, all the details that are ordinarily desired.

3. *Massive Safflorite.*—In a letter to the Editors, dated May 3d, Mr. L. W. McCAY states that to avoid misunderstanding two incomplete sentences in his article upon massive safflorite, on p. 370 of the May number, should read as follows: "He further appears to doubt the accuracy of the statement which appears so often in Breithaupt's Paragenesis to the effect that speiskobalt and safflorite appear together, *the former above the latter*, and suggests it as well to examine the specimens belonging to the Freiberg collection with a view of discovering what this safflorite really is. The specimens from Bieber, Schneeberg, Reinerzau and Wittichen, which Sandberger had opportunity to examine, exhibited no indications of the two minerals occurring together *as stated.*" The interpolations requisite for a proper understanding are in italics.

4. *The Santa Catharina Meteorite;* by ORVILLE A. DERBY. —Subsequent examination, which unfortunately could not be communicated to this Journal in time to prevent the publication of the note in the January number, shows that the observations there recorded were based on errors of identification of the elements of the stony crust that envelops fragments of the meteorite. This crust proves to be due to the cementation to the iron of the elements of the soil and disintegrated rock on which it rests, but so altered in physical aspect and chemical composition that with the imperfect means of separation then at command and my limited experience in dealing with partially altered and reconstituted rocks, I was completely deceived regarding its true nature and relations to the meteoric mass.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Concours National de Compensation de Chronomètres pour les températures;* by G. CELLÉRIER. Geneva, 1885.—The competition, the results of which are discussed in this volume was initiated by the section of Horology of the Society of Arts, Geneva. Fifty-four pocket and seven marine chronometers were in the competition, and an uncompensated marine chronometer was added for purposes of comparison.

It is well known that a chronometer with an uncompensated balance wheel may be regulated to keep time for any one given temperature. With a compensated balance wheel the chronometer can be regulated to keep correct time at any two given temperatures. But experience shows that, in general, the chronometer thus adjusted will not keep correct time at other temperatures than those two. Fifty years ago Dent expressed this by saying: that between the two given temperatures the chronometer gains time, that above the higher and below the lower temperatures the chronometer loses time. This *secondary* error of compensation, or *Dent's inequality*, is sometimes expressed thus: *The curve whose abscissas are the temperatures and whose ordinates are the corresponding rates is a parabola.* A goodly number of mechanical devices have been tried, at large expense of time and money, generally with indifferent success, for the purpose of correcting this peculiar irregularity. Yet strange to say the present investigation is, we believe, the first extensive one for ascertaining the facts about this inequality. It gives us a large number of observations. M. Cellérier has obtained from them some important conclusions.

Some chronometers had steel spiral springs and some had palladium. The whole were kept at a temperature as near to 5° Centigrade as practicable for five days, then in like manner for successive periods of five days each, the temperatures were 10°, 15°, 20°, 25°, 30°, 35°, 30°, 25°, 20°, 15°, 10°, 5°, 35°; that is, fourteen periods in all. Between each two periods one day was omitted to allow the warm box and the time-pieces to assume throughout the new temperature. In the final discussion the last period was discarded. The position throughout was dial up.

In the competition of the time-pieces four observed elements were considered: the average daily error, the average difference of rate in the two isothermal periods, the average error per degree in the correction of the primary inequality, and the average secondary error. But the principal scientific interest of the work consists in the facts and discussions about the secondary inequality.

The pieces that had palladium springs were compared with those that had steel springs, with the following results. Upon plotting the curves to present the observed secondary error those of the palladium springs had no really typical form. They were sinuous and of varied shapes but of small amplitude. On the other hand the curves for the steel springs were much more inclined to a parabolic form, but had greater amplitudes. In short, steel springs in the hands of a good adjuster permit us to know by a simple formula the rate of the chronometer, while palladium springs give smaller but more irregular secondary errors. The average of the secondary errors for palladium springs was about 70 per cent of that for steel springs. If these five points of merit be taken together, viz: regularity of daily rate, identity of rate in isothermal periods, smallness of principal error of compensation, smallness of secondary error, and regularity of secondary error, the author says that the steel and the palladium springs stand on an equality.

The mean acceleration for the first seven periods differed from that of the last seven. The curve for the secondary error also differed very decidedly in the two periods. In general it approached much more nearly to the parabola in the second than in the first half of the time. The cause of this is supposed to have been that most of the time-pieces had been adjusted only a short time before the trial, and therefore had not in the earlier periods attained such regularity of action as in the later periods.

The bulletins of daily rate, with the reductions, are given in full, and the various curves for the secondary errors are presented in the plates. These curves of course include all errors of observation of unknown irregularities. The facts developed by this competition cannot fail to throw light on the unknown causes of the secondary error. N.

[Copies of this memoir may be obtained from Mr. Florend, 15 Maiden Lane, New York City; the price is 20 francs.—EDS.]

2. *Annals of the Astronomical Observatory of Harvard College;* vol. xiv, Pt. II.—Observations with the Meridian Photometer during the years 1879–1882, by EDWARD C. PICKERING, Director, aided by Arthur Searle and Oliver C. Wendell, Assistants in the Observatory. pp. 327–512. Cambridge, 1885.—The first portion of this important work on Astronomical Photometry, embracing the observations with the Meridian Photometer at the Harvard Observatory, is contained in Part I of volume xiv, and was briefly noticed in this Journal at the time of its publication (xxviii, 319). Part II, now issued, contains a comparison of the results of the Harvard observations with the catalogue of Ptolemy, with those of both Herschels, and with all the modern catalogues which give estimated or measured magnitudes of stars. The Suspected Variables, Discordant Observations, the Distribution of Stars, and Errors of Catalogues are subjects of separate chapters.

3. *Thunder Storms.*—The New England Meteorological Society has issued a circular containing an announcement of a special subject of investigation for the summer of 1885, with advice, which will be sent to all desiring it on addressing Professor W. M. Davis, Secretary of the society, Cambridge, Mass., together with instructions and blanks for records. The council of the society asks the assistance of members and observers, and of all persons interested in this investigation, not only in keeping records but particularly in extending the observers in their neighborhood.

4. *Van Bemmelen.*—In the last number of this Journal, on page 422, Van Beneden is a typographical error for Van Bemmelen.

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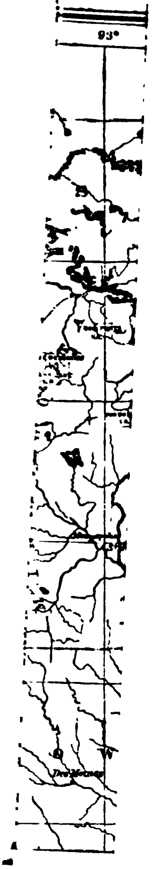
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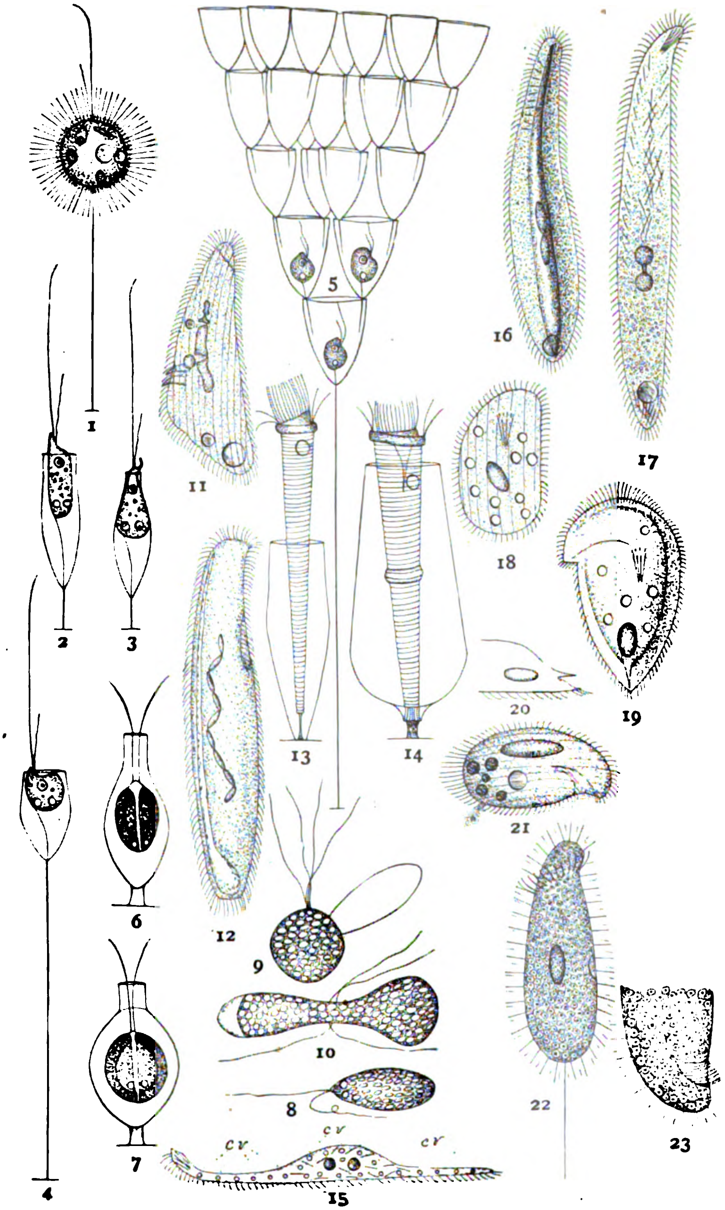

FRESH-WATER INFUSORIA.

Geology of the Sea Bottom in the Approaches to New York Bay.

By A. Lindenkohl.